SCIENCE

FRIDAY, MAY 14, 1915

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CHARLES SEDGWICK MINOT[1]

I WISH to dwell in this paper not on the scientific attainments and successes of Charles Sedgwick Minot, but on the mental and moral qualities which his career illustrates and which made him what he was.

Young Minot did not follow the traditional course of education for the son of a well-to-do Boston lawyer. He did not go to Harvard College, but to the Massachusetts Institute of Technology and his first degree, that of bachelor of science, was obtained from that technical school. His major subject in that school was not the common one of engineering, but the uncommon one of natural history. He later pursued his studies in this unusual subject at Leipzig, Würzburg and Paris. Then, returning to Boston, he took the degree of doctor of science at Harvard University in 1878, again in the subject of natural history. His education, therefore, showed his determination in following his bent. and his independence in parting from his boyhood associates and his family's habitual practise in regard to the education of sons.

Then, as now, the only career open to students of natural history was a professorship in some branch of that subject, but this was not the career to which Minot looked forward. His studies were all histological and embryological, and their most practical and useful applications seemed to him to lie somewhere in the field of medical science and education.

Two years later he accepted two ap-

[1] Address before the Boston Society of Natural History at a memorial meeting held on March 17, 1915.

pointments in connection with Harvard University; one an appointment as lecturer in embryology in the medical school; the other an appointment as instructor in oral pathology and surgery in the dental school.

These appointments were procured for him with some difficulty, for he was not a doctor of medicine, and it was an unwelcome idea for the medical faculty that any instruction whatever should be given in the medical school by a person who had never taken the degree of doctor of medicine.

He accepted both these appointments with alacrity, although dentistry was not recognized then as a medical specialty, and immediately showed himself to be a competent lecturer and laboratory teacher in subjects which depended on the facile use of the microscope by both teacher and students. The place he took in the dental school had, just previously, been filled by Arthur Tracy Cabot, who had shown by his acceptance of that appointment his sympathy with the efforts of the university to lift and improve the dental school and the dental profession, and his prophetic belief that the relations between dentistry and clinical medicine were to become much more intimate than they had been.

In 1883, Minot was advanced to the position of instructor in histology and embryology, and this subject was given a satisfactory place in the curriculum of the medical school. There was still resistance to the appointment of a teacher who did not hold the degree of doctor of medicine, but Minot had, in three years, proved not only that he was the vigorous teacher, but that he had business qualities which would make him a remarkably good director of a laboratory for the instruction of medical students. He devised an excellent method of buying microscopes for the whole class and loaning them to students for a term fee which was sufficient to keep every microscope in repair and in time to repay their whole cost.

He studied every detail of the furniture and fittings of a medical laboratory and decided on the shape and the size of the desk room which each student needed. He made highly intelligent use of the card catalogue for his growing collection of embryological specimens, for his library and for his student records. He became expert in everything relating to the conduct of a laboratory and set a good example to all the other teachers who were conducting laboratories in the medical school. As the school was then in the process of changing from a school in which the lecture predominated to a school in which the laboratory predominated, Minot became more and more useful to the medical school as a whole.

In the year 1887, it was possible to appoint him to an assistant professorship of histology and embryology. At the expiration of the usual term for an assistant professor (five years) he was made professor of histology and human embryology, and in this appointment, with its new title, Minot's special subjects and his high merits both in teaching and in research were fully recognized.

Between 1881 and 1883, the medical faculty planned and erected a new building for its own use on Boylston Street, at the corner of Exeter Street—a building in which laboratories occupied a large part. Minot obtained for his courses an excellent laboratory of his own planning. There, in twenty years, he built up his unique embryological collection; a monument to his insight, skill, industry and power of inspiring others with his own zeal. In less than twenty years this building became inadequate for the best development of the medical school, and the new buildings of 1905 began to be planned. The fundamental consideration in planning and constructing the new buildings was to adapt them thoroughly to the new method of instruction in

medicine—a method which relied chiefly on individual instruction and laboratory work. Minot's careful study of the best laboratory conditions for small sections, in well-lighted and well-ventilated rooms, with a desk for each student, was taken up again and contributed much to the final success of the architect's plans. The accommodations for the department of histology and human embryology conformed to Minot's conception of the present and future needs of his department and served as a type for the laboratories of other departments in the school.

It became possible to enlarge the number of teachers employed in the department, and its intimate connection with the teaching of anatomy was recognized. When Dr. Thomas Dwight, professor of anatomy since 1883, died in 1911, the school was fully prepared to recognize the fact that anatomy and histology belonged together. In the mean time, the James Stillman professorship of comparative anatomy had been endowed and to that Professor Minot had been transferred in 1905. No professor of anatomy was appointed to succeed Dr. Dwight, but in 1912 Minot was made director of the anatomical laboratories in the Harvard Medical School. This action of the faculty and the corporation crowned Minot's professional career as a student and teacher of natural history, applied in medical education. By clear merit he had made his way and the way of his department in the school and without a medical degree had become the head of anatomical teaching in a medical school. Under him in the anatomical department were two assistant professors, one of whom was called assistant professor of anatomy and the other of histology. Fourteen other teachers were employed in the department of anatomy and histology, three of whom bore the title of histology and embryology, Minot's original subjects in the medical school.

Minot's advance through the medical school was not facilitated by a yielding or compromising disposition, or any practise of that sort on his part. On the contrary, he pursued his ends with clear-sighted intensity and indomitable persistence; suavity and geniality were not his leading characteristics in discussion or competition and he often found it hard to see that his opponent had some reason on his side. Like most independent and resolute thinkers, he had confidence in the soundness of his own reasoning, and in the justice of the cause or movement he had espoused.

He was upright in every sense of that word. His loyalty was firm and undeviating, whether to an ideal or a person or an institution, and affection and devotion, once planted in his breast, held for good and all.

His book on "Human Embryology" published in 1892 made him famous throughout the learned world, so that he was elected to learned societies in Great Britain, Italy, France, Germany and Belgium; as well as to all appropriate American societies. He also received honorary degrees from the universities of St. Andrew's (Scotland), Oxford (England), Toronto (Canada), and Yale. He enjoyed calmly and simply the honors thus paid to his scientific attainments and services by well informed and impartial judges.

In 1913 he was Harvard exchange professor at the universities of Berlin and Vienna, where he gladly availed himself of many opportunities to expound to his German colleagues the advances in natural history, including medicine, which were due to American investigators.

His hair and beard were now whitening, but he felt all the ardors of youth, and among them, fervid patriotism. In scientific investigation Minot showed imagination, penetration and eagerness, but also caution. In 1907 he gave a course of lectures at the Lowell Institute on "Age,

Growth and Death" and made them the basis of a book published the following year. For him, the subject meant cell metamorphosis, with which he had been familiar through all his studies in histology and embryology, but what he sought in this subject of "Age, Growth and Death" was a scientific solution of the problem of old age which should have—I quote his words—"in our minds, the character of a safe, sound and trustworthy biological conclusion." He ventured to think that some contemporary students of the phenomena of longevity had failed to exercise sufficient caution in forming their conclusions. Nevertheless, Minot was a scientific optimist; full of hope for perpetual progress and for useful results at many stages of the long way. These characteristics appeared clearly in the following passage, taken from the first lecture of that course at the Lowell Institute:

> I hope before I finish to convince you that we are already able to establish certain significant generalizations as to what is essential in the change from youth to old age, and that in consequence of these generalizations now possible to us new problems present themselves to our minds, which we hope really to be able to solve, and that in the solving of them we shall gain a sort of knowledge which is likely to be not only highly interesting to the scientific biologist, but also to prove in the end of great practical value.

There spoke the cautious, modest, hopeful scientist, expectant of good. Such is the faith which inspires the devoted lives of scientific inquirers.

CHARLES W. ELIOT

THE STIMULATION OF GROWTH[1]

I

THE growth of living organisms differs from that of crystals in three essential features. While the crystal grows only in a supersaturated solution of its own substance, living organisms can grow indefinitely in even a very low concentration of their nutritive solution; second, the nutritive solution need not and perhaps should not contain the compounds found in the cells, but only their split products, while in the case of the crystal the substance of crystal and solute must be identical. And thirdly, growth leads in living cells to the process of cell division as soon as the mass of the cell reaches a certain limit. Needless to say this process of cell division can not even metaphorically be claimed to exist in a crystal.

The fact that the cell can grow in a very low concentration of its nutritive solution, and the further fact that the nutritive solution only needs to contain the building stones for the complicated compounds of the cell, find their explanation in the assumption of the existence of synthetic enzymes or synthetic mechanisms in the cell.

The problem of growth is linked with that of death and immortality, since it would follow from our definition that the growth of a cell should go on eternally in a proper nutritive solution and under suitable conditions of temperature, provided that the synthetic catalyzers last and that they synthetize their own substance.[2] This is apparently true for bacteria and perhaps also for protozoa. Weismann has claimed immortality for all unicellular organisms and for the sex cells of metazoa, while he concedes mortality to the body cells. Leo Loeb recognized that immortality may be claimed also for the cells of malignant tumors, like cancer, for he had found that when he transplanted cancer cells on other animals the cells of the original cancer and

[1] Read at the meeting of the National Academy in Washington, April 19, 1915.

[2] This latter assumption leads to the connection of the problem of growth with that of autocatalysis as suggested first by the writer in 1906 and worked out subsequently in the papers of Wo. Ostwald and T. B. Robertson.

not the cells of the host grow into a new cancer. He suggested in 1901 that this claim might be extended to somatic cells in general.

The idea suggests itself that not only the germ cells can be immortal, but that perhaps also the somatic cells, like connective tissue cells, might, under certain conditions, live for a long period, much longer than the individual life of the organism of which they were a part, that they might perhaps also be immortal in the same sense as the ovum is.[3]

Returning to the same problem in 1907 he added the following remarks:

There exists another very striking phenomenon in the growth of malignant tumors, to which I called attention in my first communications on the transplantation of tumors, namely the fact that tumor cells have apparently an unlimited existence and that they seem to resemble in this respect the germ cells. It is certain that their life and growth exceeds that of the other somatic cells of the individual, from which they are taken. But at present we are not yet justified in saying that the tumor cells differ in this specifically from certain other somatic cells. It has been tacitly assumed thus far that the somatic cells of the metazoa have only a limited existence, but no attempt has been made to determine exactly the possible duration of life of somatic cells. We must therefore consider the possibility that certain somatic cells possess the same apparently unlimited duration of life as somatic tumor cells. . . . This seems to be a biological problem of great bearing to which the experimental investigation of tumors has led, and it might be possible to decide experimentally whether or not other cells resemble tumor cells in this respect.[4]

The experimental decision seems to have been furnished, since Carrel has succeeded in keeping connective tissue cells from a chick embryo alive for over three years, and these cells are still growing and dividing. It should be added, however, that similar attempts with other cells have not yet met with the same success.

While thus theory and experience seem to agree to some extent, a closer examination of actual conditions reveals a somewhat different and more complicated situation. The egg cell, for which Weismann claimed immortality, can not grow and develop and will die quickly if it is not fertilized at a certain stage of its existence. The cells in the body will not grow constantly as our definition seems to demand, but their growth is followed by a period of rest from which they may be aroused by special substances or by a wound. Moreover, all differentiation of form in animals and plants depends on the fact that the different parts grow with different velocities, since otherwise all organisms would be perfect spheres.

In reality then the resting condition of a cell seems to be as much a part of real life as growth and cell division. Yet the definition from which we started is apparently correct, and it may be that we have to define the additional conditions which make a resting cell possible and which will wake a resting cell from its slumber.

II

In the usual treatment of the problem of growth the increase of mass of the whole organism is taken into consideration. While this method is adequate for the study of the relation of nutrition to growth, it is not adequate for the study of the stimulation of growth. In the latter case we must remember that it is the individual cell which grows, and that we must therefore study the mechanism of this stimulation in the individual cell and not in the organism as a whole. The ideal object for this study is the egg cell, since we can observe it in the condition of rest as well as of cell division and growth.

Since usually cell division follows growth and is possibly a consequence of the increase of mass of the cell, this rule does not

[3] Leo Loeb, "On Transplantation of Tumors," *Jour. Med. Res.*, VI., 28, 1901.

[4] Leo Loeb, "Beiträge zur Analyse des Gewebewachstums," *Arch. f. Entwicklungsmech.*, XXIV., 655, 1907.

always hold in the egg cell, where as a rule immediately after fertilization a series of cell divisions follow without any increase of mass of the egg. The egg, when divided into two or more cells, does, as a rule, not weigh more (and may possibly weigh a little less) than the original egg cell before it began to divide. This exception from the rule that cell division is preceded by growth of the cell is not real, since the egg cell is at first much larger than the ordinary body cell of the growing organism. If the relation between size of cell and cell division exists we must expect that the egg cell after it is fertilized must first undergo a series of cell divisions without any growth, until each cell of the original egg has been reduced to the size of the cell characteristic for the species. Only after this has happened can the ordinary cycle of growth of the cell with subsequent cell division begin.

The writer is suspicious that even in eggs where we notice at first cell division without growth, in reality growth may take place. Such eggs as those of the sea urchin consist largely of reserve material which is gradually transformed into the peculiar state which we designate as living protoplasm (and which may differ from non-protoplasmic material in the possession of synthesizing enzymes or mechanisms). In the first stages of cell division this transformation of reserve material into living material may occur, and this transformation is the real growth which we observe in the bacteria and later on in the cells of metazoa, but which is not directly visible in the first stages of cell division in the egg.

The unfertilized egg immediately before fertilization is usually unable to divide even under the most perfect conditions. With all the food existing in a hen's egg the germ can not grow unless it is fertilized, while this growth takes place after a spermatozoon has entered the egg. There exists, therefore, a mechanism by which the same egg cell can be in a state of rest in which growth is inhibited. What is the nature of this peculiar inhibitory mechanism and what is the mechanism by which the entrance of a spermatozoon abolishes this inhibition? The experiments on artificial parthenogenesis[5] allow us to give a partial answer to this question.

In the case of certain eggs, *e. g.*, the egg of the sea urchin, the entrance of a spermatozoon is followed immediately by a striking change in the surface of the egg. The latter surrounds itself with the so-called fertilization membrane. If we induce this membrane formation by certain chemicals (*e. g.*, a short treatment with a fatty acid) the eggs when put back into normal sea water will begin to develop at a low temperature and may reach the larval stage. But at the temperature of the room or even of the ocean the eggs may begin to develop, but they will perish the more rapidly the higher the temperature. On the other hand, the eggs if fertilized with sperm will develop at room temperature. What causes this difference? The answer is that the alteration of the surface of the egg induced by a fatty acid initiates development but is not sufficient to guarantee a normal development at ordinary conditions. For this purpose a second treatment is required and this can be given in the form of a short treatment with a hypertonic solution or a longer treatment with lack of oxygen. After the egg has received the second treatment it can develop into a normal larva at room temperature. I am suspicious that even a third factor may have to be supplied, since the mortality of the parthenogenetic larvæ is greater than that of the normally fertilized eggs.

Why is it that the membrane formation, or more correctly an alteration of the sur-

5 The reader is referred to the writer's book on "Artificial Parthenogenesis and Fertilization," Chicago, 1913, for details and literature.

face layer of the egg, which may or may not result in a membrane formation, starts the development of the egg? The writer had found that the fertilized egg can not develop if deprived of oxygen, but that development begins again instantly if oxygen is admitted. From this and other observations he concluded that fertilization by sperm as well as artificial membrane formation induced development by raising the rate of the oxidations in the egg, and this surmise was confirmed by actual measurements by O. Warburg as well as by Wasteneys and the writer.[6] It was found that the entrance of a spermatozoon into the egg raises the rate of oxidations from 400 per cent. (*Arbacia*) to 600 per cent. (*Strongylocentrotus purpuratus*) and that artificial membrane formation by butyric acid raises the rate of oxidations to exactly the same amount.

The changes which determine this characteristic rise in the rate of oxidations of the egg are situated at the surface of the egg, in its cortical layer. The process underlying membrane formation can be called forth by any substance which causes cytolysis—that form of destruction of the cell which results in the transformation of a cell into a mere shadowy skeleton. Any cytolytic agent will induce membrane formation and also development in the unfertilized egg, if it is allowed to act on the superficial layer of the egg only, *i. e.*, if the egg is removed from its influence after the membrane formation. If it is not removed the whole egg will undergo cytolysis and can no longer develop. But such eggs will still show the rise in the rate of oxidations which follows artificial membrane formation, thus indicating that the sudden rise in the rate of oxidations which we notice after artificial membrane formation depends only upon the alteration of the surface of the egg, regardless of the condition of the rest of the egg.

The forces which induce the egg cell to develop are, therefore, localized at the surface of the cell and consist in a change (possibly a cytolysis) of the cortical layer of the egg. We do not know how this change induces the rise in the rate of oxidations upon which development depends, but from Warburg's work it appears probable that the oxidations in the sea urchin egg are due to a catalysis by iron. This would indicate the possibility that in the cytolysis of the cortical layer of the egg the iron would be transformed from a condition where it is unable to act as a catalyzer into a condition where it can act in this capacity.

We have mentioned the fact that all cytolytic agencies call forth the membrane formation in the unfertilized egg. Such cytolytic substances (the lysins of the bacteriologist) are also contained in the blood and cell extract of each animal; only with this limitation that the cells of our own body are immune against the action of our own lysins, but not against the lysins in the blood and cell extract of other animals. I was able to show that we can call forth membrane formation and development in the sea urchin egg with foreign blood, *e. g.*, ox blood, or with the extracts of foreign tissues, but not with their own blood or tissue extract. Wasteneys and the writer could show later that this method can be applied generally for artificial parthenogenesis. This immunity of the egg towards the lysins of its own body we may explain on the assumption that the lysins contained in foreign blood can enter the cell, while the latter is impermeable for the lysins contained in the blood or tissue extract of the same species. If it were not for this immunity, all the eggs would be induced to

[6] There are indications that other processes are also initiated or accelerated by fertilization, but this may be omitted from consideration in this connection.

develop before they leave the ovary. This is not the case.

The work on physiologically balanced salt solutions has brought out the fact that the permeability of the cells in a body may undergo variations and when this happens it is conceivable that the lysins in the blood may induce eggs to develop in the ovary. Leo Loeb states that 10 per cent. of the eggs in the ovary of a guinea-pig may show a beginning of parthenogenetic development, and certain spontaneous tumor formations in the human ovary may find their explanation in this way. In other words, it is not excluded that one form of limited growth may be due to the immunity or impermeability of cells to blood of the same species.

The question then why an unfertilized egg can not grow and why a fertilized egg possesses the power of dividing and growing is therefore answered in the sense that both conditions depend apparently upon the condition of the surface layer of the cell.

The most important fact for our present problem is the observation that the alteration which starts the development of the egg is to some extent reversible. The history of the egg is such that after a number of cell divisions the final stage of the unfertilized egg ready for fertilization is reached. If at that stage it is fertilized by sperm or induced to develop by artificial means the processes of cell division and growth will continue; if not, the egg will soon die. There is a third possibility. The unfertilized egg may start to develop, then stop and go practically, though not entirely, back into the state in which it was before starting to develop.

The clearest case of this kind was observed in the egg of the Californian sea urchin. When the unfertilized egg of *Strongylocentrotus purpuratus* is treated with a hypertonic solution the eggs may begin to segment into two, four, or eight or sixteen cells, but then they cease developing and go back into the resting condition in which they were before the egg started dividing, with the exception of one condition which will be mentioned later. In the place of each of the original eggs we have now two, four, eight, etc., smaller cells. The observation is of importance for the theory of fertilization, because it disposes of the idea once held by Boveri that eggs are in the resting stage because they are lacking the apparatus for cell division; these eggs went into the resting stage again in spite of the fact that they possessed the apparatus for normal cell division. If the cells of such an egg are at a later time fertilized with sperm, they form a fertilization membrane and develop. They will develop also into larvæ if they only receive the butyric-acid treatment without the corrective factor. The original treatment with the hypertonic solution provided these eggs permanently with the corrective effect.

What caused these eggs which were segmenting to go back into the resting stage? I am inclined to assume that in these eggs the change in the cortical layer which started the development was gradually or suddenly reversed. We should expect this to betray itself in a lowering of the rate of oxidations. Wasteneys and I have found indeed that unfertilized eggs of *purpuratus*, which show an increase in the rate of oxidations after a treatment with a hypertonic solution, show a lower rate if examined after some time. It seems then possible that the change in the cortical layer which leads to a rise in the rate of oxidations is under certain conditions reversible.

These are not the only cases of reversion. I noticed that if the development of the eggs of *Arbacia* is induced either by a

treatment with butyric acid or by alkali, and if the eggs are afterwards prevented from developing (by putting them for a certain length of time into sea water containing NaCN) they will go back into a resting condition from which they can be aroused again by a treatment with sperm. We suspect that in this case the reversion in development is also accompanied by a reversion in the rate of oxidations.

We see then that our definition of a cell as being constantly ready to grow and segment is not strictly fulfilled even in the case of the egg cell, which, according to Weismann, we may consider as immortal. Instead we see that the egg cell can apparently alternate between a resting condition and an active condition, and that the nature of the cortical layer of the egg determines in which of the two conditions the egg exists.

From this we might conclude that our original definition, that each cell will grow and multiply eternally, may hold after all if we add the fact, that in the egg cell a variation in the nature of the cortical layer may start or inhibit cell division and growth. We may next ask: Does this addition also satisfy the facts we find in the adult body where the cells come to rest unless they are called into active growth again by a wound or by the not definitely known causes of tumor formation? Or, in other words: Is it only a change in the cortical layer which condemns the cells of the adult body to rest and those of the young body to grow?

Unfortunately, our task is not so easy. The unfertilized egg which is ready for fertilization will die comparatively rapidly, unless it is fertilized by sperm or treated by the methods of artificial parthenogenesis. We can prolong its life by suppressing its oxidations. Before the egg is mature its duration of life seems longer. If the eggs of the starfish are allowed to mature they die in a few hours if not fertilized; if they are prevented from becoming mature they live much longer. It is not known that anything similar to this exists in the somatic cells of the adult animal. Until such knowledge is acquired we must be prepared to admit that the resting cell of an adult organism is in a condition which is not comparable to that of the unfertilized egg.

III

We know that the growth of resting cells in a body may be induced if the blood contains certain substances which differ for different kinds of cells. One of the most recent and most striking observations in this direction was that of Gudernatsch, who found that in the tadpole of a frog or a toad, whose legs usually do not begin to grow until it is several months old, the legs can be induced to grow out at any time, even in very young specimens, by feeding them with the substance from thyroid glands. No other material seems to have such an effect. The thyroid contains iodine, and Morse states that if instead of the gland iodized amino-acids are fed the same result can be produced. We must draw the conclusion that the normal outgrowth of legs in a tadpole is also due to the presence in the body of substances similar to the thyroid in their action (it may possibly be thyroid substance) which is either formed in the body or taken up with the food.

That the phenomena of larval metamorphosis are independent of the influence of the central nervous system has been amply demonstrated. Thus I could show in 1896 that if we cut through the spinal cord of an amblystoma larva the metamorphosis of the body in front and behind the cut takes place simultaneously. Uhlen-

huth showed that if the eye of a salamander larva is transplanted into another larva the transplanted eye undergoes its metamorphosis into the typical eye of the adult form simultaneously with the normal eyes of the individual into which it was transplanted. These and other observations of a similar character show that substances circulating in the blood are responsible for the phenomena of growth in this case.

A very instructive observation on the rôle of internal secretion on growth was made by Leo Loeb. When the fertilized ovum comes in contact with the wall of the uterus it calls forth a growth there, namely, the formation of the maternal placenta (decidua). Leo Loeb showed that the corpus luteum of the ovary gives off a substance to the blood which alters the tissues in the uterus in such a way that any contact with any foreign body induces this deciduoma formation. The case is of interest since it indicates that the substance given off by the corpus luteum does not induce growth directly, but that it allows mechanical contact with a foreign body to induce growth, while without the intervention of the corpus luteum substance no such effect of the mechanical stimulus would be observable. The action of the substance of the corpus luteum is independent of the nervous system, since in a uterus which has been cut out and retransplanted into the animal the same phenomenon can be observed.

All these cases agree in this, that apparently specific substances induce or favor growth not in the whole body, but in special parts of the body. This recalls the idea of Sachs that there must be in each organism as many specific organ-forming substances as there are organs in the body. When this statement was made by Sachs the facts on the specific effect of internal secretion were unknown. To-day we can say that Sachs's theory is certainly supported by a stately array of facts.

There may also be substances which affect growth more generally. This is indicated in the apparent connection of acromegaly and giantism with diseases of the hypophysis and in the inhibition of longitudinal growth after extirpation of the thyroid.

We are, however, unable to answer the question as to how these substances induce the cells to grow. Are the resting cells in the body in the condition of the unfertilized egg and does the thyroid in Gudernatsch's experiment produce an alteration of the cortical layer of the cells from which the legs grow out, similar to that caused by the butyric-acid treatment of the egg? It would not be safe to make such an assumption at present, since we do not even know whether the products of internal secretion act directly on the growing cell or only in some indirect way. We only know that conditions of rest in the cells may be interrupted by the production of certain substances in the body or by their introduction in the form of food; and conversely we may suspect that the rest of the cells may have been enforced by the presence of other substances (or cells) in the blood antagonistic to the former.

The idea that the products of internal secretion or certain substances taken up in the food do not act directly upon the cells whose growth they influence, but indirectly through an alteration of metabolism, is strongly supported by the interesting observations of Geoffrey Smith. Claude Bernard and Vitzou had shown that the period of growth and moulting of the higher Crustacea is accompanied by a heaping up of glycogen in the liver and subdermal connective tissue. Smith found that during the period between two moultings when there was no growth the storage cells are seen to be filled with large and numerous

fat globules instead of with glycogen. He also found that in the *Cladocera* "the period of active growth is accompanied by glycogen—as opposed to fat—metabolism." He observed, moreover, that if *Cladocera* are crowded at a low temperature the fat metabolism (with inhibition to growth) is favored, while at high temperatures and with no crowding of individuals the glycogen metabolism is favored. In the latter case a purely parthenogenetic mode of propagation is observed, while in the former sexual reproduction takes place. The effect of crowding of individuals is apparently due to products of excretion, which then act on growth and reproduction indirectly by modifying the "glycogen metabolism" to "fat metabolism."

IV

Factors which directly inhibit growth have been discovered by Jas. B. Murphy, of the Rockefeller Institute. It was known that tissues can not be successfully transplanted into a different species. Murphy discovered that this rule does not hold for the chick embryo. Any kind of tissue, even human, will grow if transplanted to such an embryo. This growth of the transplanted tissue will stop, however, when the chick is ready to hatch, and Murphy found that this is due to the development of a certain type of cells in the chick embryo at that period, namely, the lymphocytes. Murphy found, moreover, that he could put adult mice and rats also into the condition of tolerance to foreign tissues when he destroyed their lymphocytes by an exposure to X-rays. As soon as the lymphocytes are formed again foreign tissues can not grow any longer on the animal. In this case we have a definite inhibition of growth by the action of lymphocytes which collect around the transplanted piece. It is not yet possible to state to what extent this observation on the inhibition of growth can be generalized.

We shall see later that possibly the opposite may also be true, namely, that certain cellular elements may have an accelerating effect on growth.

V

When a wound is made, cells which had been at rest may begin to grow. In many lower animal organisms and in plants whole organs may be induced to grow as a consequence of a mutilation. These phenomena are known under the name of regeneration. The name indicates the power of a living organism of restoring lost parts.

We can see from a physicochemical viewpoint why a cell should be endowed with a power of growing indefinitely, since we only need to assume the presence of suitable synthetic enzymes in the cell; but we fail to see from the same viewpoint why an organism should have the power of restoring lost parts. Weismann and others have tried to account for this power in a metaphysical way which was shown to be in conflict with the facts.

The statement that regeneration consists in the restoration of lost parts is not always the exact expression of the actual facts. In plants, *e. g.*, we notice—in the majority of cases—not a restoration of the lost parts but the outgrowth of one or more dormant buds which are often at some distance from the seat of injury. There has been some discussion whether in view of this fact we can say that regeneration exists in plants. This merely verbal difficulty disappears if we disregard the metaphysical sense of the term regeneration and realize that the essential feature of the phenomenon is the fact that if we wound living organisms, cells or anlagen which had ceased to grow suddenly begin to grow. Thus the problem of regeneration becomes a problem of

growth and the real question is: How can the process of wounding induce growth in cells which had been at rest and would probably have remained so during the whole term of life of the individual? It is not the wound in itself which induces the growth; since in plants the growth of new organs does as a rule not occur along the area of the wound, but at some distance where an old bud existed or a new one is formed. The distance of the growing or regenerating part from the wound may be quite considerable.[7]

It has been stated that the isolation of the parts is the cause of the new growth following the wound. Thus if a leaf of the tropical plant *Bryophyllum calycinum* is cut off from the plant each of the notches will give rise to a new plant when the leaf is kept in a moist atmosphere. (This is the regular way of propagating this plant.) But no such growth will occur as long as the leaf is kept in connection with the plant (and the latter is normal). Here we seem to have a clear proof of the generally accepted statement that isolation of parts leads to regeneration. The idea seems to be still further corroborated if we cut off a leaf with a piece of the main stem of the plant and suspend it in moist air. In this case no new plants will grow from the notches of the leaf. This again seemingly supports the idea that the separation of the part from the whole is the cause of growth since the leaf attached to a piece of the stem is less isolated than a leaf without any stem. Yet it can be shown that if we diminish the degree of isolation of the leaf still more by leaving it attached to a stem still possessing the opposite leaf the power of the first leaf to form new plants in its notches is enhanced again. The experiment can be made in the following way. From the same plant let be taken (1) an isolated leaf, (2) a leaf with a piece of stem, (3) a leaf with a piece of stem and the opposite leaf; let all leaves be suspended in a moist chamber with their tips submersed in water. The first and third specimen will form new plants in the submerged parts of their leaves in a comparatively short time, while the second will do so not at all or considerably later than the others.[8] Hence the experiment shows first that complete isolation induces the leaf to form new plants, that less isolation will inhibit this phenomenon, and that still less isolation will again call forth the regeneration. It is therefore plainly impossible to state that isolation is the cause of regeneration.

Those who make such a statement usually assume the existence of inhibiting influences in the plant and explain the effect of isolation on regeneration or growth on the assumption that the isolation frees the part from this inhibiting influence of the whole organism. We should be forced to assume that in the normal *Bryophyllum* there exists an inhibiting influence which prevents the buds in the notches of the leaves from growing, while when the leaf is cut off the notches are released from this inhibiting influence. To this idea we can agree, but then the question arises: What is this inhibiting influence? Thus it is a common experience that in the isolated stem of *Bryophyllum* only the apical buds will grow, while if we cut off the apical buds the next lower buds will grow out, and so on. Hence the growth of the apical buds inhibits the growth of the lower buds. Some more recent authors have suggested that a kind of nervous influence is responsible for this inhibition. But we have already mentioned a number of facts which show

[7] The process of healing, *i. e.*, of the closing of the wound, should be kept distinct from the phenomena of growth which constitute regeneration.

[8] A full account of these experiments on *Bryophyllum* will be published in the near future.

that in animals substances circulating in the blood influence growth independently of the central nervous system. In *Bryophyllum* I have recently made some experiments which seem to agree with this humoral theory of the control of growth. It can be shown in *Bryophyllum* that if a part *a* inhibits the growth in a part *b*, the presence of *b* favors growth in *a*.

We will illustrate this by two experiments. When we suspend in the moist air of a closed vessel a stem of *Bryophyllum*, whose tip, roots and leaves have been removed, only the buds in the uppermost node will grow into shoots. The growth of the apical shoots inhibits the growth of the lower buds. But if we isolate a node near the apex and suspend it in the same moist chamber, as a rule no regeneration will occur in this node; only if we leave the lower parts of the stem connected with the apical node can the latter regenerate in moist air. Hence the lower part *b*, in which regeneration is suppressed by the topmost part *a*, is necessary or helpful for the regeneration of the top *a*.

The same effect can be produced if, instead of leaving the node near the apex in connection with the lower pieces of the stem, we leave it in connection with one leaf or part of one leaf. In this case also growth of the bud will occur in the moist air. As we have already stated, the leaf is inhibited from forming new shoots in its notches through the connection with the stem. Hence the stem which inhibits the growth of shoots in the leaves is helped by the leaf in its own regeneration.

This seems to agree at first sight with the idea first suggested by Sachs that the specific shoot-forming substances do not exist in sufficient quantity in the topmost part of the stem and that they must be supplied to this piece either by a leaf or by a larger piece of stem. And on the same principle might be explained the inhibition of the top piece upon the regeneration of the lower nodes. To this assumption the simple objection is possible that a long stem contains material enough to form a dozen shoots or more, as can be shown if the stem is cut into shorter pieces. Each of the lower nodes will in this case form two new shoots. Yet the formation of two shoots at the apical node will prevent the formation of shoots at the lower nodes, although there is enough material to form shoots in every node.

It can be shown that the upper nodes if isolated will promptly form shoots if put into a thin layer of water. Hence the presence of a leaf or of the greater part of a stem enables the upper node to form shoots in moist air either by supplying it with the necessary amount of water or by establishing a flow of material. Where we have a closed circulatory system as in animals we know that the heart action can only maintain a circulation if the blood vessels are filled with blood. The writer is not sufficiently familiar with the circulation in plants, but botanists do not assume the existence of a closed circulatory system. But, however this may be, the presence of a sufficient quantity of water seems to be the prerequisite for a constant flow of substances in the conducting vessels. If we assume that the anatomy of the conducting vessels determines a flow of substances to the apex and second that the buds in that region hold *all* or practically all the formative or specific material which induces growth, the inhibition of growth in the lower buds becomes clear.

Hence we are inclined to explain both the inhibiting effect of an organ *a* upon the regeneration in *b* as well as the accelerating effect of *b* upon *a*, from the following three factors: first, the peculiarities of the anatomy of the conducting vessels in the plant;

second, the necessity of a flow for the transport of substances inducing growth; and third, the retention of these substances (even beyond need) by or near the organs which are first induced to grow or regenerate.

Such a view is supported by the older experiments of the writer on *Tubularia*. *Tubularia* is a hydroid consisting of a hollow stem attached with stolons to a solid substrate, usually piles or rocks, and bearing at its free end a polyp. Only the region behind the hydrant and the tips of the stolons show growth, the cells in the stem do not grow any more. We can, however, induce the cells in any cross section of the stem to grow into a polyp if we cut off the rest of the stem above or beneath it. How does this operation induce growth? The first idea might be that this is due to the wound; the wound, however, can only be the indirect cause, since we perceive such an outgrowth of polyps also from the tips of the uninjured stolons.

I observed that when we cut a piece *ab* from the stem and if we suspend it in sea water, both ends *a* and *b* form polyps, but that the oral end forms its polyps considerably more quickly than the aboral end; and the difference in time may be from one or two weeks to one or two days, according to the temperature and the species used for the experiment. We may, however, induce the aboral end to form its polyps just as quickly as it would form at the oral end if we prevent the formation of the oral polyp by cutting off the oxygen supply at this end. Hence the suppression of the formation of the oral polyp accelerates the formation of the aboral polyp; and, conversely, the formation of the oral polyp retards the formation of the aboral polyp. This might at first appear to be explainable on the assumption that only a limited amount of material for polyp formation was present in the stem, but this assumption is rendered untenable by the fact that if we cut the stem into a number of pieces each piece will form two polyps, the oral one always more quickly than the aboral one. This shows that the stem has material enough not for two, but, if necessary, for a dozen polyps or more. We understand the facts, however, on the assumption that the material necessary to induce the cells at the front edge to grow into a polyp collects first at this end and is held here; and that only later it can also gather at the opposite end. This is almost the same assumption as that made to explain the phenomena in *Bryophyllum*. But in the case of *Tubularia* the visible phenomena directly support our assumption. I noticed that the formation of a polyp is always preceded by a dense collection of certain pigmented cells from the entoderm which are carried like the blood corpuscles of higher animals in the fluid which circulates through the stem. These red or yellowish cells always collect first at the oral end of a piece cut out from a stem of a *Tubularia*, but if we withdraw the oxygen from this end they collect at once at the aboral end. I mentioned that the tips of stolons may grow out into polyps without a wound. Whenever this happens the formation of a polyp is preceded by a gathering of the red cells in this tip. The question then arises: Why do these red cells gather first at the oral end of a cut piece of the stem? I am not in a position to give a definite answer to this question. I suspect that phenomena of agglutination may play a rôle in this case. All I wanted to indicate was the connection which exists between the transport of special material and the localization and inducement to growth.[9]

[9] These older observations of the writer may possibly assume a greater significance in view of the work of Jas. B. Murphy concerning the rôle of lymphocytes in the prevention of the growth of

I am inclined to see another confirmation of this interpretation in a well-known observation of Morgan on the regeneration of *Planarians*. He found that if a piece be cut from the body at right angles to the longitudinal axis the head will form along the whole cut edge of the piece, while if a piece be cut out obliquely a tiny head will form in the foremost corner of the cut edge. As Bardeen suggested, this would find its explanation on the assumption that the head formation is induced by the collection of certain material which will collect along the whole front when the piece is cut out of the body at right angles, while it is bound to collect in the foremost angle when the piece is cut out obliquely.

VI

When we summarize all the facts we may state that it may be inherent in each cell to grow and divide eternally under suitable conditions; and that we can understand this condition on the simple assumption of the existence of synthetic ferments or synthetic mechanisms in each cell which are formed from the food taken up by the cells. In reality, however, things do not happen in this way in multicellular organisms, and not even in their egg cells. The unfertilized egg can in most cases not grow even under the most favorable conditions and is doomed to die in spite of its potential immortality, unless it is fertilized or treated with the methods of artificical parthenogenesis. The condition of rest or growth depends in this case apparently upon the condition of the cortical layer of the egg and the alteration in the rate of oxidations connected with this condition.

In the body, cells may be at rest or growing, and we do not know whether the conditions which determine rest are identical with those determining rest in the egg. We know, however, that specific substances circulating in the blood can induce certain resting cells in the body to grow and that these substances differ apparently for different types of cells. It may be that in the body substances antagonistic to these may enforce the inactivity of the cells.

foreign cells in a body, to which reference was made in an earlier part of this paper.

And finally we come to the conclusion that the circulation in animals or the flow of substances in plants is an important factor in the phenomena of cell rest and cell growth, inasmuch as circulation or flow determine or influence the distribution of formed cells or non-formed elements which induce or influence growth. The phenomena of regeneration seem to find to a large extent their explanation in the fact that a wound or mutilation leads to a gathering of formed or non-formed elements in spots where without the mutilation they would or could not have collected.

JACQUES LOEB

THE ROCKEFELLER INSTITUTE FOR MEDICAL RESEARCH,
NEW YORK

ALASKA SURVEYS AND INVESTIGATIONS

THE United States Geological Survey is dispatching 12 parties to Alaska to continue the systematic surveys and investigations that have been in progress for the last eighteen years. Of these parties three will be sent to southeastern Alaska, one into upper Chitina region, one to Port Valdez; two will work in the Turnagain Arm-Knik region; one will make investigations in the Yukon-Tanana region, and two in the Ruby-Kuskokwim region, and another will traverse the little-known area lying between the Ruby district and the Tanana River. One party will be engaged in general investigations in different parts of the Territory. These parties will sail from Seattle during May, so as to take full advantage of the field season. All the men needed for the work have been engaged, and the pur-

chase of horses, supplies and equipment is well under way.

One of the most important of the undertakings is the extension of the surveys in the Ruby district, on the Yukon, and in the adjacent regions. C. E. Griffin and G. L. Harrington will undertake the surveys in the Ruby district proper, which is now an important gold-placer camp. R. H. Sargent and J. B. Mertie will carry surveys southward to Takotna, on Kuskokwim River. H. M. Eakin will explore the region lying between the mouth of Cosna River, a tributary of the Tanana, and the Ruby district. The only other work in the Yukon basin is that of Eliot Blackwelder, who will make a geologic examination of the White Mountains, southwest of Circle.

The region lying between Knik and Turnagain Arm, tributary to the proposed government railroad, has been only partly mapped, and here both geologic and topographic surveys will be undertaken. The preparation of the topographic base map will be undertaken by one party under the leadership of J. W. Bagley, and the geology and mineral resources will be studied by another party under S. R. Capps.

B. L. Johnson will complete his detailed study of the geology and mineral resources of the Port Valdez district and will also investigate the mineral resources of other parts of the Prince William Sound region.

Much of the Copper River region has been surveyed in previous years. There still remains, however, the upper Chitina basin, where no geologic work has been done. This work will be undertaken by F. H. Moffit, assisted by R. M. Overbeck.

The detailed topographic mapping adjacent to Juneau, in southeastern Alaska, begun last year, will be continued by D. C. Witherspoon. The base map of this important gold lode district is essential to an exhaustive study of the district which will be undertaken next year.

The mineral resources of the Ketchikan district have been under investigation at different times in the last fifteen years, and the results embodied in reports. Detailed surveys of the two most important copper-bearing areas of the Ketchikan district have been made. Much of the district has been geologically mapped, but the work is still far from being complete, and the investigation of the geology and mineral resources in this field is to be extended by Theodore Chapin.

The marked industrial advancement in southeastern Alaska has created a great demand for information about the available water-powers, which George H. Canfield has been detailed to investigate. He will also carry on stream gaging in cooperation with the Forest Service.

The hot springs of Alaska are of importance, as many are used as local sanitariums. As no information about them is available, they are to be investigated this summer by G. A. Waring, who will visit the hot springs of Ketchikan and Sitka, in southeastern Alaska; one near Circle and the Baker and Chena hot springs, in the Tanana Valley; and one in Seward Peninsula, about 60 miles north of Nome.

Alfred H. Brooks, geologist in charge of the survey's Alaska investigations, will be engaged in office work until about the end of June. He will then leave for Alaska, and his work will probably include investigations in the Iditarod, Fairbanks and Valdez districts.

AT THE OHIO STATE UNIVERSITY

The following letters have been exchanged between the president of the Ohio State University and the dean of the College of Agriculture:

OHIO STATE UNIVERSITY,
COLUMBUS

My dear Professor Price: Since your remark this morning that you would not remain as professor of rural economics I feel impelled to write you and make an urgent appeal for you to reconsider that decision. My judgment is that you have a quarter of a century of service ahead of you here in a field not well occupied anywhere in the country. You have the esteem and good will as well as the confidence of your colleagues. I can not but feel that you would be sacrificing a highly useful career if you should leave the uni-

versity. It would give me personal satisfaction and pleasure to nominate you at the maximum salary. It would be a great disappointment to me and I think also to your friends if you should persist in your determination to leave the service in the university.

Think this matter over deliberately and let me have assurance of your willingness to remain.

Very cordially,
W. O. THOMPSON

April 21, 1915

April 27, 1915

PRESIDENT W. O. THOMPSON,
Campus.

My dear President Thompson: Your letter of April 21 came to hand and I have delayed answering it until I had time to consult with some men, both on the campus and off of it, who have the welfare of the university at heart, and men in whom I know you have confidence.

I have thought the matter over carefully and what I have to say is said deliberately and without feeling. In answering your urgent appeal to remain in the university I can not refrain from reviewing some of the things that have happened in the college of agriculture during the twelve years that I have been dean.

I came here twelve years ago to fill the position of dean. I had only been out of college six years, most of my associates and colleagues had been my teachers. The college was small, the enrollment was only 243, about one seventh of the total enrollment of the university. The esteem in which the college was held in university circles was not high. Townshend Hall and the old horticultural building represented the material equipment of the college. No winter courses were given, no extension work was done, no farmers' week was held, no three-year courses existed and combination courses with other colleges were unthought of. This year the enrollment in the college is 1,478, nearly one third of the total enrollment of the university. The college of agriculture of Ohio State University is surpassed in enrollment, as reported in a recent number of SCIENCE, only by Cornell and the University of Wisconsin. The standards of the college of agriculture have been raised, five buildings have been built, 250 acres of land have been added to the university farm. Most cordial relations exist with all the agricultural organizations of the state, and the work is held in high esteem by the farmers.

All of this progress and development has not been due to the work of any one man, but rather to the faithful, conscientious work of every one connected with the college, but I insist that in this growth and development I have done my share.

To be summarily demoted without assigning any cause and without explanation, as was done by the recent action of the board of trustees, I resent. I believe that I, my associates and colleagues, and the people of the state are entitled to know why such action was taken.

It is not that I am enamored with administrative work, but one thing for which I have always prided myself has been frank, open dealing with every one and I do not feel that I have been accorded such treatment by you and the board of trustees. However, I could overlook all of that and take up the work of a department if I thought conditions justified it. But I believe that conditions in the university are fundamentally wrong in that the encroachment of the business administration upon the academic has brought about a condition that is rapidly growing intolerable to members of the faculty. Such action as the board has recently taken in reference to me will intimidate your faculty, but it will not give it a sense of permanency that is conducive to constructive, efficient work, neither does it develop the spirit of loyalty.

I appreciate the cordial request that you have made of me to remain in the faculty. But under conditions as they now exist I do not believe it would be wise and very respectfully decline.

It is not without regret and heartaches that I lay down the work of the college in which I have invested my very self for the past twelve years. In retiring I do so without apologies for what has been accomplished during my administration, and I sincerely hope that my successor may have more loyal support from the president and the board of trustees than I have had.

I am,
Very truly yours,
HOMER C. PRICE,
Dean

P. S.—As a matter of information I am referring copies of this correspondence to members of the board of trustees and to the president of the alumni association and am giving it to the press.

THE WASHINGTON UNIVERSITY MEDICAL SCHOOL

On the 29th and 30th of April the new buildings of the Washington University Med-

ical School in St. Louis were dedicated. On the morning of the 29th exercises were held in the Assembly Hall of the school at which the keys of the buildings were formally presented to the acting chancellor of the university by the architect. The visiting delegates were then presented to the chancellor and president of the corporation. The delegates were as follows:

Harvard University: President Abbott Lawrence Lowell.

Yale University: Dean George Blumer.

University of Pennsylvania: Dean William Pepper.

Brown University: Mr. Augustus Levi Abbott.

University of Pittsburgh: Dean Thomas Shaw Arbuthnot.

St. Louis University: Dean Hanau Wolf Loeb.

Medical Corps of the United States Army: Captain Thomas Dupuy Woodson.

Western Reserve University: Dean Carl August Hamann.

Lafayette College: President John Henry MacCracken.

Tulane University of Louisiana: Professor Rudolph Matas.

St. Louis Medical Society: Dr. Robert Emmet Kane.

Knox College: President MacClelland.

University of Michigan: Professor Frederick George Novy.

University of Missouri: Acting-Dean Guy Lincoln Noyes.

University of Bellevue Hospital Medical College: Vice-Dean Samuel Albertus Brown.

New York Academy of Medicine: Dr. Edward Dix Fisher.

Missouri State Medical Association: Dr. Frank Joseph Lutz.

The University of Edinburgh: Professor Lindsay Stephan Milne, University of Kansas.

Central Wesleyan College: President Otto Edward Kriege, Professor Albert William Ebeling.

Detroit College of Medicine and Surgery: Dean B. R. Shurley, Professor Charles Godwin Jennings.

Purdue University: Professor Oliver Perkins Terry.

University of Minnesota: Professor James Edward Moore.

Drury College: President James Gilmer McMurtry.

University of Cincinnati: Professor John Ernest Greiwe, Dr. Christian Holmes.

Johns Hopkins University: Professor Theodore Janeway.

Missouri Valley College: Mr. Alphonzo Chase Stewart.

Missouri Botanical Garden: Professor George Thomas Moore.

Leland Stanford Junior University: Dr. Harold Phillip Kuhn.

Dennison University: Dr. E. B. Packer.

University of Kansas: Professor John Sundwall.

Rockefeller Institute for Medical Research: Dr. Simon Flexner.

Memorial Institute for Infectious Diseases and Rush Medical College: Dr. James Bryan Herrick.

American College of Surgeons: Dr. Major Gabriel Seelig.

University of Illinois: Dr. Dean D. K. A. Steele, Professor A. C. Eycleshymer.

An address was then made by Dean Opie, of the Medical School, who outlined the early history and reorganization of the school and the ideals which it represents. He was followed by Dr. William H. Welch, of Johns Hopkins, who spoke of the development of clinical teaching in American medical education and of the success which had attended the introduction of full-time clinical teaching at Johns Hopkins, and which is under consideration at Washington University.

After-luncheon addresses were made on the lawn of the medical school by President Lowell, of Harvard, and President Vincent, of the University of Minnesota. Dr. Lowell spoke on the importance of preventive medicine as a public service, and of the necessity of a broad general education as a basis for the training of the physician. Dr. Vincent spoke of the position graduate studies should hold in medical education. Dr. Henry S. Pritchett, president of the Carnegie Foundation for the Advancement of Teaching, the third essayist of the afternoon, was unable to be present and his paper was read by Professor Lowes, of the college faculty. His paper was on "Medical Education in Missouri." After the addresses the guests of the university were entertained at a garden party.

In the evening a banquet was held at the St. Louis Club at which Mr. Robert S. Brookings, president of the corporation of Washington University presided. Responses to toasts were made by President Hill, of the University of Missouri, former Governor David R. Francis, Dr. Abraham Jacobi and Dr. W. H. Howell.

Friday the 30th was known as Alumni Day and in the morning talks were given by Dr. W. T. Porter in behalf of the alumni of the St. Louis Medical College, and Dr. Robert Terry in behalf of the alumni of the Missouri Medical College. These two institutions were united to form the Washington University School in 1899. Dr. Fred T. Murphy then spoke to the alumni in behalf of the medical school faculty.

In the afternoon Dr. Geo. Dock spoke on the relation of the academic hospital to the community. He was followed by Surgeon General W. C. Gorgas who spoke on the eradication of yellow fever and malaria in Havana and in the Canal Zone, and the possibilities that preventive medicine holds for the future.

In the evening academic exercises were held in the university chapel on the university campus followed by a reception in the building of the school of fine arts. The following honorary degrees were given at the exercises:

Doctor of Science: Dr. W. T. Porter; Dr. O. E. Folin, and Dr. Theodore Janeway.

Doctor of Laws: Professor R. H. Chittenden, Dr. W. C. Gorgas, President H. R. Hill, President A. L. Lowell, President George E. Vincent, Dr. F. P. Mall, Dr. Abraham Jacobi, Dr. Simon Flexner, Dr. W. H. Welch, Dr. S. J. Meltzer, Professor W. H. Howell, Dr. Rudolph Matas.

Doctor of Laws (in absentia): Professor Nathaniel Wille, University of Christiania.

Opportunity was provided in the program for the inspection of the laboratories of the medical school and the affiliated Barnes and St. Louis Children's Hospitals. The laboratories were opened in September and consist of two four-story and basement buildings 209 × 56 feet. In the north building are located the administrative offices, library, assembly hall, laboratories of preventive medicine and surgery and the department of anatomy. The south building is occupied by biological chemistry, physiology and pharmacology. A third building five stories in height and 232 × 60 feet which completes the group is on the hospital lot directly across the street from the other laboratory buildings. The basement and first floors are occupied by the out-patient dispensaries of the hospitals. On the second floor is located the clinical laboratory of the department of medicine, while the department of pathology occupies the third and fourth floors. Animal quarters and runways are provided on the roofs of all the buildings. The three laboratory buildings were erected at a cost of $1,200,000 which brings the outlay for new buildings for the medical school, including the hospitals, to over $3,000,000.

One of the interesting features of dedication week was the presentation to the Washington University Medical School of a number of manuscripts and papers of William Beaumont by his granddaughter Miss Irwin. Included among these are the original manuscripts and notes of Beaumont's experiments upon Alexis St. Martin and the agreement entered into by St. Martin to accompany Beaumont, for a period of two years for the purpose of experimentation. Dr. F. J. Lutz spoke of Beaumont as a practitioner and Dr. Joseph Erlanger on Beaumont as an investigator. A room has been set aside in the library of the medical school to house the manuscripts, known as the Beaumont room.

On April 28 Dr. Simon Flexner delivered a popular lecture before the Washington University Association on "The Control of Infective Diseases."

In connection with dedication week of the medical school of Washington University a series of four lectures on "Protein Metabolism" was delivered by Dr. Otto K. Folin. The subjects were as follows:

"The Utilization of Food Protein."

"Tissue Metabolism with Special Reference to Creatinin."

"Protein Metabolism with Special Reference to Uric Acid."

"The Occurrence and Significance of Phenols and Phenol Derivatives in the Urine."

SCIENTIFIC NOTES AND NEWS

For the meeting of the British Association to be held at Manchester from September 7 to September 11 next, under the presidency of Professor Arthur Schuster, Sec. R. S., the following sectional presidents have been appointed: Section A (mathematics and physics), Sir F. D. Dyson; B (chemistry), Professor H. B. Baker; C (geology), Professor Grenville Cole; D (zoology), Professor E. A. Minchin; E (geography), Capt. H. G. Lyons; F (economics), Dr. W. R. Scott; G (engineering), Dr. H. S. Hele-Shaw; H (anthropology), Dr. C. G. Seligman; I (physiology), Professor W. M. Bayliss; K (botany), Professor W. H. Lang; L (education), Mrs. Henry Sidgwick; M (agriculture), Mr. R. H. Rew. Evening discourses will be delivered by Mr. H. W. T. Wager on the "Behavior of Plants in Response to Light," and by Dr. R. A. Sampson, astronomer royal for Scotland.

A bust of Sir Archibald Geikie will be placed in the Museum of Practical Geology, London, where there are already busts of all previous occupants of the post of director-general of the British Geological Survey and of the museum, as well as of several other distinguished geologists. Sir Archibald Geikie was connected with the survey for nearly forty-six years, during nineteen of which he was director-general. A committee representative of the universities and the principal scientific institutions and societies of the United Kingdom has been formed to carry out the proposal. Contributions for the fund should be made to the honorary treasurer, Mr. J. A. Howe, curator of the Museum of Practical Geology, Jermyn Street, London, S.W.

Dr. Henry S. Munroe, professor of mining in Columbia University and senior professor in the university, will retire from active service at the close of the present academic year. Professor Munroe began teaching at Columbia in 1877 and became professor in mining in 1891.

On April 30 Professor James Monroe Bartlett had completed thirty years of continuous service as chemist of the Maine Agricultural Experiment Station. This period includes the entire history of the station itself. In recognition of this unusual length of service in the same institution a reception in Professor Bartlett's honor was held in the station building on the evening mentioned, and he was presented with a commemorative volume. This volume was composed of a series of congratulatory letters from nearly all of the 109 different persons, now living, who have, at one time or another, been associated with Mr. Bartlett in connection with the work of the station.

At the first annual meeting of the District of Columbia Chapter of the Society of the Sigma Xi the following officers were elected: Marcus Benjamin (Columbia), president; Isaac King Phelps (Yale), vice-president; Marcus Ward Lyon, Jr. (Brown), secretary; Daniel Roberts Harper, 3d (Pennsylvania), treasurer; Frederick Leslie Ransome (California) and Cornelius Lott Shear (Nebraska), councillors.

At the annual convocation of the University of Alberta, in Edmonton, on April 28, the honorary degree of D.Sc. was conferred on Mr. W. F. Ferrier, mining engineer and geologist of Toronto. Mr. Ferrier was for nine years an officer of the Geological Survey of Canada. He has made extensive donations to the museum collections at the University of Alberta and has assisted in building up the Geological Museum equipment.

The Adams prize of the value of about $1,200 for 1913–14, has been awarded by the University of Cambridge to Mr. G. I. Taylor, Smith's Prizeman in 1910. The subject selected was "The Phenomena of the Disturbed Motion of Fluids, including the Resistances encountered by bodies moving through them."

According to a Paris cablegram the French Institute has announced that the Osiris prize, which this year amounts to $36,600 because no award was made in 1912, has been awarded chiefly for discoveries in medicine. Drs. Chantemesse and Vidal, discoverers of anti-typhoid vaccines, will divide $10,000, while an equal amount will go to Dr. Vincent, whose researches resulted in the find-

ing of ether vaccine. Various ambulances receive $12,000, and the remainder is placed in reserve.

THE Paris Geographical Society has awarded a gold medal to Dr. J. Scott Keltie for his services to geographical science.

MR. EDWARD W. PARKER, of the United States Geological Survey, for many years the government coal statistician of the division of mineral resources, leaves the government service to accept a responsible position with the anthracite mining companies. Mr. H. D. McCaskey has been appointed chief of the division of mineral resources of the survey to succeed Mr. Parker. Mr. McCaskey brings to this position experience, not only as a geologist of the survey since 1907 and section chief since 1912, but also as a mining engineer in the Philippine Mining Bureau from 1900 to 1903, and as chief of that bureau from 1903 to 1906.

DR. JOHN G. BOWMAN has been appointed director of the American College of Surgeons, founded in 1913, an organization of the surgeons of the United States and Canada. Its purpose is the advancement of the art and science of surgery. The executive offices are at 30 North Michigan Avenue, Chicago.

DR. H. T. SUMMERSGILL, superintendent of the University of California Hospital, has succeeded the late Dr. W. O. Mann, of Boston, as president of the American Hospital Association.

SECRETARY of Agriculture Houston has begun an extensive tour of the national forests to find out for himself to what extent their timber, forage, water power, recreational and agricultural resources are being developed for the public under present methods and to make a study of the administrative problems of the forest service. During May he is visiting the forests in several of the western states.

PROFESSOR KOEPLIN RAVN, an authority on the composition of soils, has arrived here from Copenhagen. He comes at the invitation of the department of agriculture and will lecture in a number of American universities on Danish farming methods.

DR. J. N. ROSE, research associate of the Carnegie Institution, accompanied by Mr. Paul G. Russell, of the United States National Museum, left on May 8 on the steamship *Tennyson,* of the Lamport and Holt Line, for South America. They expect to spend the season in Brazil and Argentina, going under the auspices of the Carnegie Institution of Washington and the New York Botanical Garden for the purpose of studying the cactus deserts of those countries. They plan to send large collections of living cacti to the New York Botanical Garden.

THREE Philadelphia surgeons are soon to leave that city for service in military hospitals of France and England. They are Dr. J. William White, surgeon and trustee of the University of Pennsylvania; Dr. R. Tait McKenzie, head of the university department of physical education, and Dr. James P. Hutchinson, surgeon at the Pennsylvania and Bryn Mawr hospitals. Under Dr. White's charge a corps of physicians and nurses will sail next month for France, where they are to form a unit in the American ambulance hospital at Paris. The operating head of the surgical department of the university corps is to be Dr. Hutchinson.

THE University of Pennsylvania Museum has received a report from Dr. Clarence Fisher, leader of the Eckley B. Coxe, Jr., expedition to Egypt under the auspices of the museum, giving an account of the work accomplished up to the early days of March. Pending the arrangements for a large site for operations, Dr. Fisher was permitted to do excavating at the base of the Second Pyramid of Giza (Gizeh), and has had some excellent results.

THE following men have accepted invitations to carry out investigations in Nela Research Laboratory, National Lamp Works of the General Electric Company, during the coming summer: Dr. W. E. Burge, acting head of the department of physiology, University of Illinois; Dr. A. H. Pfund, associate professor of physics, Johns Hopkins University and Dr. S. O. Mast, associate professor of

zoology, Johns Hopkins University. Mr. B. E. Shackelford, fellow in physics in the University of Chicago, has been appointed Charles F. Brush fellow for the summer of 1915.

The annual joint meeting of the Phi Beta Kappa and Sigma Xi honorary societies of the University of Pennsylvania was held in Houston Hall on the evening of May 3. Dr. John A. Brashear made the address on the subject of "Great Telescopes of the World and Discoveries made by their Use." An informal reception followed the address. The societies alternate in choosing a speaker, and this year the choice fell to Sigma Xi.

Dr. Ulric Dahlgren, professor of biology in Princeton University, lectured on May 12 on "The Production of Light by Animals" at the closing exercises of the lecture season of the Wagner Free Institute of Science, Philadelphia.

The monument to be erected to Cesare Lombroso at Verona, the work of the sculptor Bistolfi, was to have been unveiled at the International Pellagra Congress scheduled for next October. As the congress has been postponed until 1916, the committee in charge of the monument has postponed the dedication.

Dr. Jay W. Seaver, for twenty-five years director of the Yale gymnasium and professor of hygiene in the university, died suddenly from heart disease at Berkeley, Cal., on May 5, at the age of sixty years.

William Harlow Reed, curator of the museum and instructor of geology in the University of Wyoming, noted for his collections of vertebrate fossils, died at the age of sixty-seven years on April 24.

Mr. Daniel W. Edgecomb, inventor, astronomer and manufacturer of telescopes, has died at his home at Fairfield, Conn., at the age of seventy-five years.

Mr. Richard Lydekker, F.R.S., known for his work and writings on natural science, died on April 16 at the age of sixty-five years.

Sir William Richard Gowers, F.R.S., eminent as a specialist on diseases of the nervous system, died on May 4, aged seventy years.

Sir Thomas Smith Clouston, a well-known psychiatrist, died at Edinburgh, on April 19, at seventy-five years of age.

Dr. M. Bernhardt, professor of neurology at Berlin, has died at the age of seventy years.

The death is announced in *Nature* of Mr. J. B. A. Légé, who made the first tide-predicting machine for Lord Kelvin. He was the constructor of signaling lamps and other apparatus invented by Admiral Sir Percy Scott and used in the navy. Among Mr. Légé's inventions are horological mechanisms, torpedoes and direct-acting petrol engines.

The next examination for the medical corps of the navy will be held in Washington, Boston, New York, Philadelphia, Norfolk, Va., Charleston, S. C., Great Lakes (Chicago), Ill., Mare Island, Cal., and Puget Sound, Wash., on or about July 6. Candidates for appointment must be citizens of the United States, between 21 and 30 years of age, and graduates of reputable schools of medicine.

The U. S. Civil Service Commission announces an examination for metallographist, for men only, to fill a vacancy in this position for service in the Engineer Experiment Station, Naval Academy, Annapolis, Md., at a salary of $2,500 a year.

The department of geology of New York University has planned a travel tour for the coming summer which will extend through the western part of the United States and a portion of Alaska. The trip is the outcome of a plan which was formulated by the department of geology two years ago. In the summer session of last year, a course of lectures preparatory to the work that will be taken up this year was given, in order that students might obtain the greatest benefit from the trip. The educational conduct of the tour will be under the direction of Dr. Raymond B. Earle, assistant professor of geology in Hunter College. The director of the department of geology in New York University, Dr. J. Edmund Woodman, will exercise general supervision. The tour will extend from July 2 to August 28 and includes a ten-day visit in Yellowstone Park, a trip to Glacier National Park, an excursion to

Alaska, with an opportunity on the return trip to visit San Francisco, Los Angeles, San Diego, Grand Canyon and the Petrified Forests. Two or three other shorter trips have been provided, one taking in Yellowstone Park and the Glacier National Park, and the other ending with the Yellowstone Park. In the case of students specializing in geology, credit will be given for the trip, under certain conditions, in the various schools of the university.

IN connection with the geographical work of the Columbia University summer session, Professor D. W. Johnson will conduct a physiographic excursion in the western United States, next summer. The party will visit the Devil's Tower, Yellowstone National Park, Glacier National Park, Crater Lake, the Yosemite Valley, Royal Gorge of the Arkansas, and the Colorado Springs and Pike's Peak region. It is probable that the new Lassen Peak volcano and the neighboring recent cinder cone will be visited, as well as the Lake Bonneville shorelines and recent fault scarps near Bingham and Provo. While in San Francisco, the party will participate in the excursions of the Geological Society of America to the San Andreas earthquake rift near Point Reyes Station, and the uplift marine terraces at Santa Cruz. Two field courses will be given: a general course on the elements of physical geography and an advanced course on the physiography of the western United States. The courses are open to students and teachers of geology and geography. It is expected that the party will leave New York about the first of July, and be gone two months.

ACCORDING to the American Museum *Journal* Mr. James P. Chapin, of the museum's Congo Expedition, after six years' absence in Africa, has arrived in New York. He brings details of the success of the expedition, not only in the work of a scientific survey but also in having lived without mishap for the extended period of six years amidst the dangers of the equatorial forest and among the negro races of Central Africa—a success due in part to the cordial cooperation of the Belgian government. Mr. Chapin brings with him about one fourth of the expedition's collections. The balance remains in the hands of Mr. Lang, leader of the expedition, who also will come out of the Congo immediately after the final work of packing and shipment is completed. The entire collection numbers some 16,000 specimens of vertebrates alone, 6,000 of which are birds and 5,000 mammals. The specimens are accompanied by some 4,000 pages of descriptive matter and 6,000 photographs. It includes full material and careful studies for museum groups of the okapi, the giant eland and white rhinoceros, besides many specimens of lions, elephants, giraffes, buffaloes, bongos, situtungas, yellow-backed duikers, black forest pigs, giant manis and chimpanzees. The ethnological section of the collection is rich in specimens of native art of the Congo, including several hundred objects of carved ivory, a revelation as to the capacities of the Congo uneducated negro. There are also seventy plaster casts of native faces from the Logo, Azande, Avungura, Mangbetu, Bangba, Anadi, Abarambo, Mayoho, Mabudu, Medje, Mobali and Pygmy tribes. Each cast is supplemented by a series of photographic studies of the individual.

THE 134th meeting of the Science Club, held March 1, 1915, was addressed by Dr. John F. Hayford, director of the college of engineering, Northwestern University, on "The Surveys and the Decision in the Costa Rica-Panama Boundary Arbitration." An innocuous uncertainty regarding the boundary between Spanish colonies became a serious dispute when these colonies became independent of the mother country and of each other, in 1825. The controversy increased in acuteness as the region in doubt became economically more important. The question, after 75 years of contention, was submitted in 1900 to President Loubet, of France, who settled the boundary on the Pacific slope to the satisfaction of both parties, but from lack of geographical information the award gave more territory on the Atlantic side to Colombia than that country had originally claimed, and de-

fined the boundary in terms incapable of interpretation on the ground. After the separation of Panama from Colombia, the question became more acute and threatened to lead to war, when the matter was again submitted to arbitration, before Chief Justice White, of the United States, with the proviso that an accurate survey should be made. The commission of engineers, two representing the parties to the arbitration, two others appointed by the arbitrator, of whom Dr. Hayford was one, accompanied by twenty-one trained assistants and a large number of laborers and porters made the survey in 1911. The survey was made under the greatest difficulty on account of the dense tropical jungle; absence of roads and trails making it necessary to rely on negro and Indian porters for transportation of supplies; and thickness of forest interfering with seeing. Nevertheless an extensive area was accurately covered, and geographical knowledge secured that is of permanent interest and value. A peak more than 12,000 feet high, hitherto unknown, was discovered, and numerous cartographical errors, including the direction of the drainage of a great area, were rectified. The decision, rendered in 1914, chooses the Sixaola River, its tributary the Yorkina, and the southern watershed of the Sixaola as the boundary, instead of the northern watershed of the Sixaola as awarded by President Loubet, and conforms to the *status quo*, since the customs have been collected at that river, and the subjects of the two countries have advanced to it from each side.

UNIVERSITY AND EDUCATIONAL NEWS

Dr. Frank J. Goodnow will be installed as president of the Johns Hopkins University on May 20. On the following day the new university buildings at Homewood will be dedicated. President Wilson will make an address; the engineering buildings will be dedicated with an address by General G. W. Goethals, and the academic buildings with an address by Professor H. C. Adams. It is expected that there will be a full attendance of alumni and former students. The committee having charge of arrangements for the inauguration and dedication is composed of President Goodnow (chairman), Dr. Ralph V. D. Magoffin (secretary), Dr. Joseph S. Ames, Dr. Murray Peabody Brush, Dr. William B. Clark, Dr. William H. Howell, Dr. Basil L. Gildersleeve, Dr. John H. Latane, Mr. George L. Radcliffe and Dr. C. J. Tilden.

The Rensselaer Polytechnic Institute announces that Mrs. Russell Sage has given $100,000 to the school, and Mr. Alfred T. White, of Brooklyn, a graduate, $50,000. The money is to be used in the erection of dormitories and a dining hall.

A trust fund of $5,000 to be known as the "Edward Tuckerman Fund," designed to increase the interest in the study of botany among the students of Amherst College, has been bequeathed to the college by the late Mrs. S. E. S. Tuckerman, wife of the late Professor Edward Tuckerman. Professor Tuckerman, who was a well known lichenologist, was a member of the Amherst faculty from 1858 until his death in 1886, holding a chair in botany and a lectureship in history.

Brown University has received $7,000 from Mrs. Jesse L. Rosenberger, of Chicago, to endow a lectureship for visiting scholars.

Professor H. H. Newman, of the department of zoology, University of Chicago, has been appointed dean in the colleges of science of that institution. The duties involve a supervision of students in the biological sciences, especially of those preparing for the study of medicine.

Dr. Stuart Weller, of the University of Chicago, has been promoted from an associate professorship to a full professorship in the department of geology.

Marcus W. Lyon, Jr., formerly assistant curator, division of mammals, U. S. National Museum, and for the past six years professor of bacteriology at Howard University, has been appointed professor of bacteriology and pathology in the George Washington University.

At Harvard University Dr. Gregory P. Baxter has been promoted to be professor of chemistry, and Dr. John L. Morse to be professor of pediatrics.

DISCUSSION AND CORRESPONDENCE

ISOLATION OF B. RADICICOLA FROM SOIL

TO THE EDITOR OF SCIENCE: I am indebted to Dr. F. Löhnis, of the United States Department of Agriculture, for two corrections which I deem it important to make with reference to the paper by Mr. Fowler and myself in SCIENCE of February 12, 1915, on "The Isolation of *Bacillus radicicola* from the Soil."

The first error is one merely of oversight, and concerns the date in which Beijerinck gave the name *Bacillus radicicola* to the legume-root nodule organism. That date should of course be 1888 and was put down as 1901 merely through carelessness on my part, and I gladly plead guilty to that.

The second error is that which is partially due to our tentative claim to priority in the direct isolation of *Bacillus radicicola* from the soil. Dr. Löhnis informs me that claims were made to the isolation directly from the soil of the organism in question by both Beijerinck and by Nobbe, et al. I do not regard the evidence put forward by Beijerinck as conclusive on that point, but there is no question at all that the second investigator named, with his coworkers, has conclusively demonstrated the presence of *Bacillus radicicola* in the soil and has also, by its isolation in pure culture, been able further to reinoculate plants grown under otherwise sterile conditions. Our neglect to take note of this last-named investigation was due to the manner of indexing pursued in the important abstract journals as well as other scientific journals which gave no useful reference to the work just referred to.

CHAS. B. LIPMAN

A RESEARCH LABORATORY FOR THE PHYSICAL SCIENCES

CONVERSATION with a number of men interested in the biological sciences and who have availed themselves of the opportunity for research work at Woods Hole, Mass., brings out the idea that one great benefit to be derived from the work there is the association with men from all parts of the country. I think all men of science will agree that the great stimulus which comes from the various meetings of scientific bodies is in the private discussion, which the men have, one with the other, on subjects in which they are particularly interested. Think what it would mean to men in the physical sciences if they could have a laboratory where for two or three months each year, at least, they could meet and carry on some research work and at the same time enjoy the fellowship of men who come from widely separated points but who are interested in their particular field.

I realize that the equipment of a laboratory for physics involves a large outlay of money and transportation of apparatus is not easy, but would the first be impossible? In other words, the object of this note is to raise the question as to whether a laboratory for the physical sciences, similar to that for the biological sciences at Woods Hole, would be a feasible and a desirable project. I believe that many chemists and physicists would be very glad to spend their summer vacation at such a laboratory if it were located, as the one at Woods Hole, where there would be a chance for an outing as well. As at Woods Hole, there would be a resident director and the laboratory would be kept open throughout the year for those who might have a year's leave of absence from their work in teaching.

That men of wealth, who would be interested in building and equipping such a laboratory, might be found does not seem such a vagary in view of what has been accomplished for special laboratories.

S. R. WILLIAMS

PHYSICAL LABORATORY,
OBERLIN COLLEGE

SCIENTIFIC BOOKS

The Salton Sea. A study of the geography, the geology, the floristics and the ecology of a desert basin. By D. T. MACDOUGAL and Collaborators. Carnegie Institution of Washington, Publication 193, 1914. 4to. Pp. 182, with plates, maps and figures in the text.

The making of a lake in a desert basin, whose floor lies below the level of the sea-sur-

face is a circumstance which when within the frontiers of civilization is too rare not to attract wide attention, much intensified by a consequent deflection of a trunk line of railway, the loss of an industry of corporation magnitude and the threatening of areas of cultivation. But in spite of vast antagonism, as measured by money and effort, this is what happened when the waters of the Colorado, first as a tiny stream, but at last as a torrent, entered the Salton Sink through the New River during the few years following 1904. If the lack of foresight which led to this is to be deprecated, it is of no meager congratulation that, precisely as the opportunity was afforded, the Desert Laboratory of the Carnegie Institution of Washington was organized and disposed toward the study of the progress of events by scientific methods. This progress is not completed, nor will be for many years, but the careful planning and continuity of study till the present moment, as witnessed by the volume before us, furnish a sure foundation, under the permanency of a stable organization such as the Carnegie Institution, for a future following of events, so that we may confidently hope at the end to have a more complete and accurate account of the complex interplay of events projected over larger places and times than has yet been produced by science. The case illustrates the necessity of the times. Mutual cooperation of students in diverse fields is becoming more and more imperative, if a satisfying solution of any problem is to be had. For a skilful observation of the Salton Sink a geographer, two geologists, several chemists and various kinds of botanists, probably a working minimum, have been needed.

The work under review may be said to have been begun by the late Professor William Phipps Blake, who, as geologist to the official U. S. Railway Survey which in 1853 had the task of exploring the southern portion of the Sierra Nevada, first comprehended the nature of the Salton basin. An account of the region written by Professor Blake only two years before his death, fittingly introduces the reader to the volume. A strong note of human interest is found in a photograph of Professor Blake standing on the travertine formation 53 years after the date of his original discovery of it. There is a historic justice in the fact that Professor Blake was permitted to see serious work begun in this desert, for his vast and intimate experience in the southwestern deserts had been but for his death of great value to it.

The dynamic geography of the region is presented by Mr. Godfrey Sykes, who bases his conclusions on the records of the early explorers, tradition and evidence observed ad hoc. The Salton Sink represents the northern extremity of the Gulf of California which has been cut off by the formation of a huge natural dam, the ridge of which extends from the Algodones Sandhills to Cerro Prieto. If this is true the major beach line identical with that of the present gulf should be, in view of tidal action, 20 to 30 feet higher than sea-level, and in view of prevailing winds, higher on the northeastern shore than on the opposite, and this Mr. Sykes finds to obtain. Rocque's map (1762) indicates that previous to 1762 or thereabout, the Colorado and Gila jointly flowed into an extensive lake, and Indian tradition comports with this. Since 1890 water from the Colorado has at various times found its way into the sink, so that the flooding of recent years was an event following the reopening of a nearly healed wound. When the flood was dammed, the waters found their way chiefly into Hardy's Colorado, and incidentally the Pattie Basin is receiving a part of the surcharge.

A different view is taken by Mr. E. E. Free, who, in a sketch of the geology and soils, regards the evidence that the basin was never occupied by the sea, any further north at any rate than Carrizo Creek. The absence of marine shells, and presence of millions of fresh-water shells, the occurrence of travertine, the amount of salt deposited and the condition at the present time of the major beach all speak for a genetic precursor of the present waters in a fresh water lake, happily called Blake Sea, which has disappeared in comparatively modern times by evaporation. The formation of the dam which excludes the

waters of the gulf has been built up *pari passu* with a subsidence of the region, bringing the lake floor below sea-level. This view, though championed with moderation, is pretty strongly buttressed by evidence. It is, however, evident that more work may profitably be directed to the problem.

It may be noted in passing that the recent flooding of a portion of the alkaline playa soil has not materially altered its salt content. If leaching out has occurred, the evaporation from the newly exposed lake floor has restored the salts to the soil.

The general position based upon geologic evidence taken by Mr. Free receives additional support from the study of the nature and amount of salinity by Dr. W. H. Ross, who finds that the concentrations and solid components of the Salton Sea to be such as to indicate an originally fresh-water body.

The increasing concentration of these various solutes is found by Dr. A. E. Vinson not to have proceeded at equal rates for all. The potassium-sodium ratio has changed, the former element having remained relatively constant while the concentrations of calcium and magnesium have increased at slower rates. The latter fact is explained by the formation of travertine, the composition of which is largely of the salts (carbonate and sulfate) of those elements.

The following paper on the behavior of organisms in brine, by Professor G. J. Peirce is introduced, aside from its intrinsic merit, evidently by reason of its future relevancy to expected conditions in the Salton Sea, as evaporation proceeds to the production of a maximum concentration of solutes.

For a single instance, it will be important to follow the racial history of the bacteria which are the agents of cellulose hydrolyses in submersed plant tissues, as shown in another paper by Dr. M. A. Brannon to occur as agents of disintegration in the Salton waters. The increasing salinity of these waters offers a succession of barriers beyond which only those forms which possess suitable capabilities of physiological adjustment may pass. It is obviously important to determine these capabilities.

The subjects for Dr. Peirce's study were found in the salt ponds on San Francisco Bay. A lively impression of the wide adaptability of the living organism is had from the persistence of numerous minute green algæ and bacteria which inhabit their waters at whatever concentrations. Of these a chromogenic bacterium responsible for the red coloration of salted codfish, has been isolated and shown to be the cause of the color of the brine and salt. It will come as a shock to those who have supposed a complete preservation to be effected by salting to know that decay may still proceed in fish saturated with salt if exposed to humid air and a moderate temperature. The fluctuations in concentration and composition of the waters of "pickle ponds" and salterns strongly umbrate the theory of balance in solutions, since it is difficult to believe that such relations can here obtain. It was also found that cell division in the protophytes varies inversely to the concentration, being halted by the higher, and stimulated by a lowering.

The deposits of tufa which characterize most markedly a vertical zone 200 feet deep, limited above by the major beach line of Blake Sea, were studied by Dr. J. Claude T. Jones, who shows conclusively its origin to be in the activity of minute algæ vegetation (*Calothrix* sp.). By a method not yet understood, certain organisms, *e. g., Chara,* caused the calcium salts to be thrown out of solution in their immediate neighborhood. When the organisms are minute and very numerous a *quasi* continuous material (sinter) is formed, found however to possess a structure which may be regarded, in a rough sense, as coralline. Imbedded in the tufa of the Salton are found snail shells. Here therefore is further evidence of the fresh-water character of the Blake Sea. The study of tufas on the slopes of ancient lakes must reveal much sure information of their previous history.

Mr. S. B. Parish contributes a paper on the "Plant Ecology and Floristics of the Salton Sink." His long previous acquaintance with the flora of the southwestern deserts places him in a position to offer a particularly complete statistical study of that portion of it included in the region in question. Of 202 species listed, 48 are introduced, and of these it is

important to note that not one has been able to establish itself under constant natural conditions. Of the remaining 131, all but six or seven are more or less widely distributed, chiefly in the surrounding country. But these few appear to be endemic, as they have not been found elsewhere. The suggestion is obvious that these have originated in the sink during comparatively recent times, while it is further pointed out by Dr. MacDougal that other species may have similarly arisen, but have succeeded in passing outwardly beyond the limits of their original home. There is an approach here to something like quantitative relations between geological age and the possible number of new specific origins.

It seems equally probable that other plants, such as the desert palm *Washingtonia filifera* and *Populus Macdougalii,* are to be referred, as to their origin, to comparatively recent dates, and this locality.

The absence of succulent xerophytes, including under this term those with water-storage roots, from this very pronounced desert region is worthy of remark, since, in the minds of many, succulence is regarded as the final expression of desert adaptation. Here the xerophytic shrub with spinose parts and other appropriate characters are the chief perennial inhabitants of the slopes and older strands, while the salt-laden alluvium of the sink-floor bears a zone of the salt-bushes, *Atriplex* spp.

The final paper of the series concerns the movements of the vegetation due to submersion and desiccation and is by Dr. D. T. MacDougal, under whose leadership the whole work has been carried forward. Recognizing the importance of the opportunity to observe the advance of plants upon an immense sterilized area especially in view of the inadequate study or total neglect of analogous earlier opportunities (one thinks of the lost one of Mont Pelée), the lavas of Hawaii, studied by C. N. Forbes excepted, the task was laid out on a comprehensive but workable scale. Sample areas or "belt transects," a mile in width, normal to the beach lines, were chosen, and these, together with sterilized islands, afforded the basis for exhaustive study. This, as the reader will have understood from what has already been said, embraced not only the vegetation, but the salt content of soil and water and other relations. Usually semi-annual visits were made for the collection of data.

The first half of the paper presents the facts concerning the reoccupation of the strands of six successive years, and a partial study of another, namely, 1913. The earlier strands of Blake Sea, untouched by the recent invasion of waters, afforded a standard for comparison, so that it was possible to measure the rate at which the facies of the new strands took on the same composition as obtains now in the old, relatively static strands. It was observed that the recession of the water was so soon followed by desiccation of the soil that wholly desert conditions were established in the course of a couple of years, and that, in consequence, the introduction of xerophytes identical with those characteristic of the ancient Blake Sea strands had been accomplished in the course of three or four years. The change from close to open formation was similarly rapid.

The transition from one environment to another as the established desert gives way to strand, and the gradual alteration of successive zones correlated with the recession of the water, together with the separation of shore and sterilized islands by extensive water ways, sets up conditions for the study of methods of dissemination and of natural selection as well as reoccupation. It is of more than incidental importance that the reoccupation of islands, and of one shore from another, was among other methods possible chiefly by the flotation of seeds and fruits as proved by many experimental tests. It is clear that in this can be seen no causal relation between the conditions and the "adaptations to flotation." Nature had otherwise been peculiarly far-sighted in furnishing to desert plants not only adaptations in harmony with their immediate surroundings, but with a possibility so remote as the occurrence of a lake! Causal relations are, however, to be seen probably in such characters as reduced superficies, thickened outer tissues, and the like, as a direct result of evaporation, and a number of such correlations have been

or can be made the subject of experimental investigation. To what extent the colloidal substances of cells, such as the mucilage dissolved in the sap, can be made use of, and how this use may be modified by the acid or alkaline content of the disperse medium is at present almost or quite unknown. The great size of tannin idioplasts and the imbibitional avidity of their colloidal content may, it is quite possible, be related, and it is similarly possible that the growth and therefore the size of other cells may depend not only on the "turgor" relations, but even more upon the imbibition pressure exerted upon their walls. The mucilage and other colloidal content of desert succulents *par excellence* may in this light take on greater significance in view of Borowikow's work, cited by MacDougal.

Much more of detail from this collection of papers could be given with more ease than to indicate, without giving an impression of meagerness in the source, the most salient points. Many people untaught in the thought of the scientist have expected vast changes in the surrounding country to follow the flooding of a large desert-inclosed area. The emersed bed of Blake Sea is, however, still a desert, and as measurement and even more superficial observation shows, the evaporation from the many square miles of water surface has had no smallest effect upon any vegetation but that immediately following recedence of the water itself. A very short span of time and the desert is restored to its own. But the opportunity of seeing what does happen has fortunately been seized, and we have in this review seen, it is hoped, that a result of signal value has rewarded.

FRANCIS E. LLOYD

McGILL UNIVERSITY

SCIENTIFIC RESEARCH AND SIGMA XI[1]

BEFORE the chapter reports are presented, it is my business for twenty minutes to address you, yours to listen; for Sigma Xi too expects every man to do his duty. We have eaten; water has been served; it is a pity that we can not now be merry. For whatever may happen to us, Sigma Xi will not die to-morrow. We have long since passed through the dangerous period of infancy; at the age of twenty-seven the death-rate is but five per thousand. And we surely are a chosen people; like the patriarchs of old, the years of our life are measured not by decenniums but by centuries.

Our first quarter century has indeed been a period of marvelous growth and fruition. As exhibited in the record and history admirably compiled by our secretary, it is one of the fairy tales of science, incredible if it were not true. The beginnings at Cornell University were small, but, like the zygote, they contained the elements which in interaction with a fit environment grew into the great organism, of which each of us is one seven-thousandth. Unlike the individuals of the species to which we belong, our corporate growth does not stop at the age of twenty-five, nor will senility follow fifty years of activity.

In a recent article an eminent American statistician states that 30.7 per cent. of Rhode Island native-born married Protestant mothers are childless. The distinguished dean of a great woman's college within a thousand miles of Philadelphia in a chapel address to the students said that it is not just to charge the decreasing birth rate to the higher education of women; although the college had been established only a few years, forty per cent. of its alumnæ were married and sixty per cent. of them had children. When birth-rate statistics are so complicated, it may not be safe to state that we are all the children of Henry Shaler Williams. But this is true, though polyandry appears on the records and we have certainly had polygamous nursing. We may indeed regard our leaders and each of us as somas of the immortal germ plasm, which seeks the light of truth:

That light whose smile kindles the universe,
That beauty in which all things work and move.

As a hand apart from the body is not a hand, as a man apart from other men is not a man, so a scientific man is not conceivable

[1] Remarks by the president of the Society of the Sigma Xi at the annual dinner given at the University of Pennsylvania on January 4, 1915.

apart from the long line of scientific worthies, great and small, who have bequeathed to us our present heritage, or from his fellow workers, old and young, without whose sympathy and cooperation no research would be possible. Our society has been founded to personify and promote the spirit of comradeship and zeal which is essential to scientific research. A century earlier, Phi Beta Kappa was established to encourage and reward scholarship in our colleges. It may be desirable to maintain the tradition of classical learning, but as service is better than culture, as the future is of greater concern than the past, so creative science is more than passive scholarship.

The activities of Sigma Xi with which I have indeed least sympathy are those which we have inherited from Phi Beta Kappa. It is a pity that we did not find an honest English name. How many of us know whether Ξυνῶνες means companions, or zealous or research? I happen to be one of the small minority of our members who read Greek for professional purposes after leaving college, but I do not know the orthodox way to pronounce our initials. In the presence of these modern Greek mysteries, one feels like the little girl who, being sent to school for the first time, rushed home on hearing the older boys recite: At 'er, beat 'er, jam 'er, eat 'er.

A pendant gold key suitably engraved is too reminiscent of the dueling scars on a face made and marred in Germany, a personally conducted advertisement of a past university student and presumably member of a corps. It has been suggested that the proposed class of associates might be entitled to wear only a smaller key. Why not let the professor carry one three inches long, and if he should become a president, make it a foot long, even though four to one would inadequately represent the difference in eminence and ability to pay for the gold? The badge may be a convenient way to pick up a congenial acquaintance in a smoking car; but would it not be better to wear a more extended label to the effect that I am not only Sigma Xi and Phi Beta Kappa too, but also a teacher of psychology, interested especially in science, education and democracy, but ready to talk about almost anything except golf and psychical research?

It is better to select and distinguish students for promise or performance in research than for high grades in classes. If interest in research or scholarship can be stimulated by such rewards they are legitimate. But when we embroider with gold braid, we are likely to bind with red tape. I wonder whether a single piece of research work has been conducted or improved because it might lead to election to the National Academy of Sciences or to an honorary university degree. The University of Königsberg has conferred the degree of its four faculties on General von Hindenburg for driving the enemy from the gates of the city, but it may be doubted whether even the doctorate of divinity will be of great assistance to him in checking the invasion. Like old china or other bric-a-brac in a laboratory, all such inherited and artificial distinctions are out of place in a democracy. If members of the National Academy received a salary for useful services, or if membership in Sigma Xi enabled students to go on with their researches then the election would be useful and desirable. It would from my point of view be better if membership in Sigma Xi depended on the option and efforts of the student and the scientific man, such as attendance at meetings and the presentation of a paper.

Even the separation of the academic sheep from the philistine goats does not seem to be a desirable segregation. A college and university education is certainly at present the gateway through which they must pass who wish to follow the paths of scientific research. But from some points of view, this is an evil necessity rather than an ideal condition. It is costly in money and precious years, in initiative and originality. The two greatest scientific men whom we have known, Simon Newcomb and William James, did not enjoy or suffer the orthodox college or university education; the same is true of the two living Americans responsible for the most important applications of science—Mr. Edison and Mr. Bell. If two academic degrees were required —four years of college culture and four years

of professional training—before the poet, the novelist, the musician, or the artist could become productive, what would be left of the literature and the art of the world? It is a system of privilege when only those can enter the professions whose parents are able to support them to the age of twenty-seven years; it postpones too long family duties and civic responsibility, and those who travel long over well-worn ways may accumulate baggage and habits which burden rather than help the exploration of new territory.

Your to-night's figurehead has been accused of being habitually "agin the administrashun," but in intention at least he is radical only as to ends, while reasonably conservative as to means. Our Society of Sigma Xi, like the university of which it is a part and much else that is best in our civilization, is a heritage handed down to us from other days and other ways, only partly adjusted to a democracy in the twentieth century. Institutions and customs should not be bent until they break; they should be permitted to reach toward the light by their own gradual growth. We can not live in a true democracy until it exists, and in the meanwhile we must do the best we can with our inherited institutions and human nature. Our society has in several directions led the way—in placing research before high grades in class work, in uniting those showing the beginnings of aptitude for research work with productive scientific men, in emphasizing and promoting the comradeship and common interests of scientific workers, in arranging scientific meetings and lectures to which all are welcome, in putting applied science on terms of equality with other research, lastly and chiefly in being one of the active agencies contributing to scientific advance.

It is anti-democratic to hold that culture is precious because it can be attained only by those having wealth and leisure, that science is noble only when it is useless. The mathematician who thanked God that his geometry was a virgin that had never been prostituted by being put to any use did not stay in America longer than he could help. Pure science may proceed on a long orbit, but it can not go off on a tangent to the real things of life. Our society has served both science and democracy by placing engineering on terms of equality with other sciences. The distinction is not between scientific discovery and practical applications, but between the discovery of new truths or new ways of doing things and the repetition of those already learned; not between the pathologist who studies diseases and the one who finds cures, but between the experimental pathologist and the routine practising physician; not between the engineer who builds bridges and the one who writes about bridges, but between the scientific man who devises new methods and the builder who copies old models. Adopting what Francis Bacon wrote in another connection:

> These two subjects, which on account of the narrowness of men's views and the traditions of professors have been so long dissevered, are, in fact, one and the same thing, and compose one body of science.

And most of all, this Society of the Sigma Xi has served democracy and science by emphasizing research work at the outset of the student's career and as the essential life work of each of our members. It is our business to promote scientific research by every method and by every motive. A correct statement of the economic value of science to society would at first sight seem incredible. It is safe to say that the applications of science have quadrupled the productivity of labor and doubled the length of human life, though it is not possible to give the exact period from which this result is reckoned. The writer would guess that so much progress has been made within from one hundred to one hundred and fifty years. In some kinds of work, as in the transportation of freight over land and some kinds of machinofacturing, the efficiency of labor has been increased a hundredfold; in others, as in agriculture, it may have been only doubled. In the period during which the efficiency of labor has been quadrupled by modern science, the annual production of wealth in the civilized world has perhaps been increased a hundred billion dollars, representing

a capital sum of two thousand billion dollars.[2] A great part of this advance is due to a few men, probably one half of it to, at most, 10,000 men. The value of each of these men to the world has been a hundred million dollars; they have been men not abler nor more productive on the average than the upper five hundred of our leading American men of science.

So far from being exaggerated this valuation of science and of scientific men neglects the decrease of disease and suffering, the increased length of life and the vast number of human beings for whom life has been made possible. It can not take account of the moral, intellectual, political and social changes wrought by science and its applications. Science has made democracy possible and has given us as much of it as we have. The applications of science have abolished the necessity of continuous manual labor from childhood to old age, they have made feasible universal education, equality of opportunity and equality of privilege, they have banished legal slavery, they have partly done away with the labor of children and the subjection of women. Science has given us freedom in the moral as well as in the material world, freedom from ignorance, superstition and unreason, the means of learning the truth and the right to tell it.

The service of science for the world is by no means complete. The productivity of labor can be again doubled by further scientific discovery; it can be more than doubled by the selection of the right men for the work they do and by correct methods of work. The value of wealth can be doubled by its proper distribution and use. Warfare, preventable disease and vice, waste and display, the futile complications of civilization, consume one half of all the wealth that is produced. We do not know the conditions of happiness and real welfare or how they are to be attained. Science should continue to press to the limit economy of production and the conservation of health and life; at the same time it should increasingly direct its methods to the control of human conduct.

Suddenly, out of its stale and drowsy lair, the lair of slaves,
Like lightning it leapt forth half startled at itself,
Its feet upon the ashes and the rags, its hands tight to the throats of kings.

On us here in America there has been thrust the duty and the privilege to carry forward the flickering torch of science and of civilization. Our society of the Sigma Xi and each of us have indeed great opportunity and great responsibility.

J. McKeen Cattell

[2] This enormous figure is based on the assumption that there are 25,000,000 people in the United States, whose productive work is worth on the average $1,000 a year and six times as many in the civilized world who earn on the average half so much, with enough left over to balance the earnings of 100 years ago.

RADIUM FERTILIZER IN FIELD TESTS

With the discovery of radio-activity by Becquerel, in 1896, and of radium itself by M. and Mme. Curie, in 1898, science revealed a property of matter and a source of energy hitherto unknown; and the facts already established, the predictions or claims made, and the general interest in the subject seemed to justify an investigation under field conditions of the possible value of radium as a fertilizer, or of radio-activity as a crop stimulant.

While possessing most of the properties of an element, reacting chemically very similarly to the element barium, radium also has the remarkable property of continuous disintegration, by continuous emanation of particles, which is accompanied by radiation of energy, called radio-activity.

Investigations show that one gram of radium emits enough heat to raise 118 grams of water one degree centigrade in one hour, or 118 calories, and indicate about enough total energy to decompose one gram of water into hydrogen and oxygen every twenty-four hours, equivalent to more than 3,800 calories, or nearly 160 calories per hour. This radiation continues hour after hour with gradual reduction to ½ the quantity in about 1,760 years, to ¼ in

3,520 years, to 1/8 in 5,280 years, and so on. Thus the total energy ultimately evolved from 1 pound of radium is equivalent to more than 70,000 twenty-four-hour days of horse-power.

Many experiments have been made to ascertain the effect of radio-activity on plant growth; and in general a distinct influence is noted, although some experimenters report negative results.

Gager[1] in summarizing his investigations states that radium acts under certain conditions as a stimulus to physiological processes, but, if used in too great strength or for too long a period, it may retard development or even kill the plant.

Fabre[2] noted some beneficial effects from emanations, using a concentration of 1½ microcuries[3] for each 2 liters of air, but injury from greater strength.

Stoklasa[4] found that radium emanations promoted germination of seeds and accelerated the growth of plants to a considerable extent. From earlier experiments he has reported increased fixation of nitrogen by bacteria.

In the spring of 1913, through the kindness of the Standard Chemical Company of Pittsburgh the University of Illinois Agricultural Experiment Station was enabled to begin a series of field experiments with radium as a fertilizer or crop stimulant. The company was deeply interested in having the experiments conducted, and the radium salts furnished to us were prepared under the direction of Doctor Otto Brill and Doctor Charles H. Viol, of the radium research laboratory of the Standard Chemical Company, the quality and strength of the preparations being thus assured.

The value of radium is about $100 per milligram and in order that the field investigation might have a direct relation to practical agriculture, the radium was used at three rates of application, costing, respectively, $1, $10 and $100 per acre; or in amounts of .01 milligram, .1 milligram and 1 milligram of radium per acre. If the effect of the application should be marked and permanent, even the initial expense of $100 per acre might be desirable.

The fields selected for these experiments were the north division of Series 200 and the south division of Series 600 of the agronomy plots on the South Farm of the University of Illinois. Each of these fields includes 144 fortieth-acre plots, two rods square, besides some divisions and border strips, making the field sixteen rods wide east and west, and thirty-eight rods long north and south.

On Series 200 and on the west part of Series 600, the radium was applied in a solution of radium barium chloride diluted with distilled water, the check plots receiving the same quantity of distilled water without radium. On the east part of Series 600 solid radium barium sulfates were applied, after diluting by thoroughly mixing and pulverizing with dry soil from the field, the check plot receiving the same weight of soil without radium. The pulverized soil was applied with a force-feed grain drill, and the solutions with an Aspinwall barrel sprayer.

The amount of radio-active substances applied in these tests was purposely made small, in order to avoid any appreciable effect of the substance other than that due to radio-activity. It is conceivable that some effect might be obtained from the application of 100 or 200 pounds per acre of mineral salts. The amount in the case of the heaviest applications was less than five pound of total salts per acre.

On both fields corn was grown in 1913 and soy beans in 1914. Owing to other experimental work involving some variations in planting, only part of Series 600 furnished comparable data in 1913, only twenty-four separate trials being provided. The work of the two years,[5] however, comprised 144 tests with corn and 240 tests with soy beans. Aside

[1] *Popular Science Monthly*, Vol. 74, pp. 222–32.

[2] *Compt. Rend. Soc. Biol.*, 70, 187, 419.

[3] A microcurie is a millionth part of a curie, the unit of measurement for radio-activity, which is the quantity of radium emanation in equilibrium with one gram of radium. In other words, the curie represents the constant or continuous energy of one gram of radium.

[4] *Chemiker Zeitung*, Vol. 38 (1914), No. 79, pp. 841–44.

[5] For detailed data see Bulletin No. 177, University of Illinois Agricultural Experiment Station.

from the corn grown on Series 200 in 1913, the average results are considered trustworthy.

EFFECT OF RADIUM ON FIELD CROPS

Increase or Decrease per Acre

Radium per Acre, Mgs.		.01		.1		1	
Crops Grown		Gain	Loss	Gain	Loss	Gain	Loss
Corn, ser. 200, 1913, bushels	West	—	1.0	2.6	—	3.9	—
	East	2.3	—	3.0	—	3.5	—
Corn, ser. 600, 1913, bushels	West	.1	—	.8	—	1.7	—
	East	—	.3	—	1.2	—	.6
Soy beans, ser. 200, 1914, bushels	West	—	.5	1.0	—	—	.2
	East	1.4	—	1.9	—	1.1	—
Soy beans, n. half of ser. 600, 1914, bushels	West	—	.2	—	1.1	—	1.5
	East	1.0	—	.5	—	2.2	—
Soy-bean hay, s. half of ser. 600, 1914, lbs.	West	275	—	—	138	—	215
	East	—	13	—	74	42	—

Series 600 possesses an unusually satisfactory degree of uniformity; but on Series 200 there are some topographic variations which influence the rapidity of "run-off" or absorption of rain, and in very dry seasons, with occasional dashing showers, when moisture is a factor of great importance, these variations appear in the crop yields. From April 11 to September 11, a period of five months, the total rainfall in 1913 was only 5.87 inches. Under these adverse conditions, even the average results from Series 200 are not considered trustworthy, notwithstanding the large number of separate trials making the averages. Even from the general averages .01 milligram of radium appears to have decreased the yield by 1 bushel on the west part and to have made 2.3 bushels increase on the east part of the field. Again, increasing the cost of radium from $1 to $10 per acre appears to have increased the yield of corn by 3.6 bushels on the west part and by only .7 bushel on the east part; and the further increase of $90 shows apparent gains of 1.3 bushels on the west and .5 bushel on the east part of this field. Of course no conclusions should be drawn from such discordant plus and minus results.

The results with soy beans on Series 200 in 1914 agree within narrow limits in showing no benefit from the radium applied the year before, the west half of the field giving slightly smaller and the east half slightly larger average yield where radium was added than on the check plots.

On Series 600 the average yields of corn in 1913 were slightly larger with two kernels per hill and slightly smaller with three kernels per hill where radium was applied, but the apparent gains and losses are all well within the experimental error of plot variation, and the general average indicates no effect from the radium. The yields of soy-bean seed on the north half of this field in 1914 likewise reveal no influence of radium, all rates of application indicating as an average slight decreases for radium on the west side and slight increases on the east side of the field. With the soy-bean hay the six general averages show no effect from radium, four results being slightly below the checks and the other two slightly above.

Thus from the two years' work we have six trustworthy average results with corn, three "for" and three "against" radium, and we have eighteen averages with soy beans, nine "for" and nine "against" radium. In all of these trials the average variation from the checks is so slight and so evenly distributed, "for" and "against," as to lead only to the conclusion that radium applied at a cost of $1, $10 or $100 per acre has produced no effect upon the crop yields either the first or second season.

Radium, with all its wonderful energy, is found upon careful analysis of the known facts, to afford no foundation for reasonable expectation of increased crop yields, when financial possibilities are considered. The rate of application mentioned by Fabre, on the basis of 1½ microcuries for each space four inches square and eight inches high, would cost about $58,800 per acre at present prices for radium.

It is true that the total ultimate energy developed in 1,760 years from 1 pound of radium will be equivalent to 35,000 horse-power days of 24 hours each; but when the time is reduced to 100 days of good crop-growing weather, and the amount of radium reduced to 10 milligrams, or to a cost of $1,000 per acre, then the energy emitted from the radium

for the possible benefit of an acre of corn during the crop season would be equivalent to 1 horse-power for 22 seconds; and the heat evolved by $1,000 worth of radium on an acre of land in 100 days would be less than the heat received from the sun on one square foot in 30 seconds.

CYRIL G. HOPKINS,
WARD H. SACHS
UNIVERSITY OF ILLINOIS

SPECIAL ARTICLES

NEW REPTILES FROM THE TRIAS OF ARIZONA AND NEW MEXICO

BEGINNING the later part of March, 1914, the University of Wisconsin paleontological expedition spent two months in Arizona and New Mexico collecting Triassic vertebrates. The time was divided chiefly between two localities, Wingate, New Mexico, nine miles east of Gallup, and along the Little Colorado River some fifty miles northeast of Flagstaff, Arizona. In both localities material was collected which should add substantially to our knowledge of the Triassic vertebrate faunas of the west.

Conspicuous among the collections are Phytosaur remains of various types. One nearly complete skull, apparently the largest yet discovered, will probably prove to be a new form.

One of the most interesting finds from the Wingate region is that of a nearly complete pelvic girdle of distinctive form. The sacrum consists of two closely united vertebræ with moderately biconcave centra. The neural arches are massive and are surmounted by stout, comparatively short spines with considerably expanded tops. The sacral ribs unite broadly with the arch and centrum, each rib being supported by a single vertebra. Distally the ribs are greatly expanded in an antero-posterior direction and are considerably thickened below and apparently down curved along the inner side of the ilium.

The upper portion of the ilium is expanded both laterally and in an antero-posterior direction into a broad, horizontal shelf. The ischia meet along the median line in a trough-like union that extends back in a horizontal tongue-shaped process. The pubes take a comparatively small part in the floor of the pelvic opening as the lower anterior portion of these elements extends directly down in a broad plate-like expansion at right angles to the vertebral column. The lower outer corner of the pubic expansion is swollen into a foot-like process, possibly to bear a portion of the weight of the creature when at rest.

All three elements enter the imperforate acetabulum in a firm union. The acetabulum is large and deeply concave and set off by a prominent raised boundary. It is directed out and down and considerably back. The girdle measures about 450 mm. from the top of the sacral spines to the lower border of the plate-like expansion of the pubis. The greatest width, at the lateral expansion of the upper portion of the ilia, is approximately 370 mm.

The massive construction of the girdle has suggested the name *Acompsosaurus wingatensis* for this new form. It is to be hoped that other material in the collections will add a knowledge of other parts of the skeleton. Figures and a more complete description of *Acompsosaurus wingatensis* will follow in another place.

MAURICE G. MEHL
UNIVERSITY OF WISCONSIN

SOCIETIES AND ACADEMIES

THE BIOLOGICAL SOCIETY OF WASHINGTON

THE 539th meeting of the society was held in the Assembly Hall of the Cosmos Club, Saturday, April 3, 1915, called to order by President Bartsch at 8 P.M., with 65 persons present.

On recommendation of the council, Mr. Ben Miller was elected to active membership.

Under heading Brief Notes, Dr. L. O. Howard called attention to a wasps' nest he had lately seen which was marked by a conspicuous blue streak. In making this nest the wasps had evidently made the blue streaked part out of a blue building paper, instead of making their pulp from the natural wood. Messrs. Bartsch and Lyon referred to the red-headed woodpeckers in the grounds of Freedmen's Hospital, stating that a few birds had remained during the winter of 1914–15, though none had wintered during 1913–1914. The species is abundant in the hospital grounds this spring. Messrs. Bartsch and Bailey

commented upon the scratching of the gray squirrels in the city parks, which Mr. Bailey said was due to infestation with fleas from their winter boxes. Suitable insect powder placed in the boxes would drive out the fleas, but was not relished by the squirrels.

The first paper on the regular program was by Dr. A. H. Wright, of Cornell University, "The Snakes and Lizards of Okefenokee Swamp." Dr. Wright said:

Seven snakes of the dry open sandy fields or pine forests of southeastern U. S. were absent on the Okefenokee Swamp islands. None of the truly Floridan ophidians and saurians were represented. Some forms occurred on the outskirts of the swamp but were wholly wanting within the swamp. The 21 species of snakes and 6 lizards were very variable in scutellation and coloration. Whether the restricted quarters and the incessant warfare and struggle for place caused the wide range of variation is not yet answerable. We had expected to find fixed peculiar stable races or subspecies because of the isolated nature of some of the islands, but segregation has not yet placed a local stamp on any of the reptilian forms. The swamp is the common source of the Atlantic coastal stream, the St. Mary's, and the Gulf affluent, the Suwannee. This factor may have had its influence on the turtles and possibly on the snakes and lizards. The swamp does not appear to be a barrier or boundary line between two decided faunal areas. It is rather a melting pot for many of the supposed cardinal characters of distinction in snakes and lizards.

Some of the interesting systematic observations are: the nontrustworthiness of the temporal scutellation and coloration in the *Elaphe* group; the need of further study in the *Tropidonotus fasciatus* assemblage; the presence of the *Osceola elapsoidea* and the *Lampropeltis doliatus coccineus* characters in one and the same specimen; the reduction of *Diadophis amabilis stictogenys* to *D. punctatus;* the non-recognition of *Ophisaurus ventralis compressus;* the presence of white-bellied adults and young of *Farancia;* the possibility of *Heterodon niger* as an end phase of coloration and a query as to the loss of the azygous in *Heterodon browni;* the overlapping in scale rows and ocular formulæ in *Storeria occipitomaculata* and *S. dekayi;* the fact that no two heads of the *Sceloporus undulatus* specimens had the same plate arrangement; and the unreliability of the mental characters in *Plestiodon*, our specimens of *P. quinquelineatus* falling into two of Cope's major groups, if determined on mental scutellation.

Dr. Wright's paper was illustrated by lantern slides showing views of the swamp, of its reptile inhabitants, and of the variations found in certain of the species. His communication was discussed by the chair and Messrs. Wm. Palmer and Hugh Smith.

The second and last paper of the program was by Dr. Arthur A. Allen, of Cornell University, "The Birds of a Cat-tail Marsh."

Observations on the food, nesting habits and structure of marsh birds showing the limitations of specialized species as to food, distribution and power of adaptability and the dominance of generalized forms were made.

Specialization in birds goes hand in hand with a high development of the instincts, but with a low degree of intelligence and little adaptability. Generalization of structure, on the other hand, occurs with a weaker development of the instincts, greater intelligence and greater adaptability. The generalized, adaptable species persist through the ages, while the specialized, non-adaptable are first to go. This is seen in the birds of a cat-tail marsh.

Seven stages are recognized in the formation of a marsh, represented in the mature marsh by zones of typical vegetation or plant associations, these associations following one another in regular succession. Similar associations and successions can be recognized among the birds if we group them according to their nesting range in the marsh. Most species are not confined to one association, although reaching their maximum of abundance in it. The generalized, adaptable species have the widest range.

The various associations with their typical birds follow:

I. The Open-water Association; important in supplying forage, but with n nesting birds.
II. The Shoreline Association, with the pied-billed grebe, a specialized non-adaptable species.
III. The Cat-tail Association, with the least bittern, coot, Florida gallinule, Virginia rail, Sora rail and red-winged blackbird, finding optimum conditions.
IV. The Sedge Association, with the long-billed marsh wren, bittern, swamp sparrow, short-billed marsh wren, and marsh hawk.
V. The Grass Association, with the song sparrow and Maryland yellowthroat.
VI. The Alder-Willow Association, with the green heron and alder flycatcher.
VII. The Maple-Elm Association, with the black-crowned night heron, and great blue heron of the marsh birds and a great variety woodland species.

Of all these species the one most generalized in habit and structure is the red-winged blackbird. It, too, is the most adaptable and is the dominant species in the marsh.

Dr. Allen's paper was illustrated by numerous lantern slides from photographs of the marsh, its bird inhabitants, and their homes, and by motion pictures of the least bittern and of the canvas-back and other ducks.

Dr. Allen's paper was discussed by Dr. L. O. Howard.

The society adjourned at 10.15 P.M.

M. W. Lyon, Jr.,
Recording Secretary